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CORRECTIONS

Monthly Weather Review, August, 1928:

Page 33, second column, second line, "41.1" should be "38.73"; third line, "27" should be "24."

Page 334, second column, Milledgeville (second rise), "41.1" should be "38.73."

MONTHLY WEATHER REVIEW

Editor, ALFRED J. HENRY

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AMOUNT OF SOLAR RADIATION THAT REACHES THE SURFACE OF THE EARTH ON THE LAND AND ON THE SEA, AND METHODS BY WHICH IT IS MEASURED[1]

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[Weather Bureau, Washington, September 26, 1928]

The time available for presenting this paper will not permit a detailed discussion of all the points involved. Therefore, for a description of pyrheliometers employed in radiation measurements I would refer you to a paper by Professor Marvin and myself on Solar Radiation and Weather Forecasting, in the Journal of the Franklin Institute, volume 202, page 273, September, 1926.

It may be added that since the above paper was written there has been published a description of important improvements which have been made in the Smithsonian silver disk pyrheliometer and which greatly decrease the sky area to which the thermal element is exposed. Also, thermo-electric pyrheliometers are finding increased favor for use in obtaining continuous records of the total solar radiation (direct + diffuse) received on a horizontal surface.

The Smithsonian pyrheliometric scale of 1913 is the accepted standard in most countries, although the Ångström standard still has adherents. Recently a radiogram from Prague, picked up by an amateur in this country, informs me that an absolute ice pyrheliometer has been constructed by Professor Volōsin of the Karlova University in that city. Details have not yet been received.

In the MONTHLY WEATHER REVIEW for April, 1927, volume 55, page 155, I have given a summary of pyrheliometric measurements made at about 100 different points, nearly all of which are inland, and frequently at considerable altitudes above sea level. In response to a recent circular I have learned of several additions and some corrections to be made to this summary.

Having thus disposed of the beginning and ending of my subject I will devote the remainder of my time to a discussion of the amount of radiation that reaches the surface of the sea.

Very few pyrheliometric measurements have been made at strictly marine stations. The list includes measurements by Thomson, at Apia, Samoa (**1**); Linke at sea between Hamburg, Germany, and Buenos Aires, Argentina (**2**); Gorczyński, at sea between Antwerp and Bangkok (**3**); Westman, at Treurenberg, Spitzbergen (**4**); at Cape Horn, Chile, during the International Polar Expedition of 1882–83 (**5**); and an important measurement at Flint Island, by Abbot, during a solar eclipse expedition in 1907 (**6**).

These observations by no means cover the seven seas, so I have sought to determine if our knowledge of meteorological conditions over the oceans, and of the relation between meteorological conditions and solar radiation intensities at the surface of the earth, is not sufficient to enable us to compute mean solar radiation intensities for different latitudes with reasonable accuracy.

Figure 1 is a chart for computing the transmission for solar radiation of dust-free air when its water vapor content is known. Using an equation developed by King (**7**) from Rayleigh's classical work (**8**) we may compute the atmospheric transmission, a_λ, for different wave lengths of light through pure dry air of any desired barometric pressure. I have made these computations for the 38 different wave lengths for which Abbot has given what he consideres the most reliable relative energy intensities, $I_{o\lambda}$, outside the atmosphere (**9**). Then by Lambert's formula, $a_{\lambda m} = a_\lambda^m$ we may determine what will be the form of the solar spectrum energy curve after the solar rays have passed through pure dry air of a given pressure. I have made the computations for pressures of 40.0 and 76.0 cm. of mercury. Considering passage through the latter when the sun is in the zenith to represent unit air mass, I have extended the computations to air masses 2.0, 3.0, and 4.0, which represent solar zenith distances of 60°0, 70°7, and 75°7.

Effecting a graphical integration by finding the area under these various curves, and applying Abbot's (**10**) latest published corrections for energy beyond the limits of his measurements, the pure dry air transmission, a'_m, for the total radiation through the different air masses, is given by the ratio of the respective areas to that for $I_o\lambda$. A smooth curve through these transmissions, which are plotted on their logarithmic scale as ordinates against their air masses as abscissas, gives curve (1).

Similarly, using Fowle's (**11**) values of the transmission of water vapor for solar radiation, $a_{w\lambda}$, and disregarding selective absorption, we obtain the transmissions represented by curves (2) to (8), inclusive, Or, stated in another way, the difference between 1.00 and the transmissions given by curves (1) to (8), gives the depletion of solar radiation by scattering in passing through dust-free air having a water-vapor content indicated by w, and a length of path through the atmosphere given by m. At sea level $w = 2.3e$, where e is the water-vapor pressure expressed in cm.[2]

To compute the depleton of solar radiation represented by the great water-vapor bands in the solar spectrum I have made use of curves given by Fowle [(12) Fig. 4], and my computed values of $I_{0\lambda}(a_{a\lambda}a_{w\lambda})$ for the values

[1] This paper by H. H. Kimball and the following paper by G. F. McEwen were presented before the joint meeting of the sections of meteorology and oceanography during the ninth annual assembly of the American Geophysical Union held at Washington, D. C., Apr. 26, 1928, in the building of the National Academy of Sciences. The joint meeting was devoted to a symposium and discussion on interrelations between the sea and the atmosphere, and the effect of these relations on weather and climate. The communications presented were on problems related to (*a*) solar radiation, (*b*) surface-water temperatures, and (*c*) atmospheric circulation. The two papers here printed were under (*a*); the other complete papers under this subhead, or references to where they have been published, appear in Bulletin No. 68 of the National Research Council which contains also references to the communications presented under (*b*) and (*c*).

[2] This relation between w and e is true only for mean values of e for a considerable period. In dealing with individual observations it may give results seriously in error.

of λ covered by the bands (**12**) [p. 408]. The plotted results give curve (16), Figure 1.

Subtracting from the values given by curves (2) to (8), inclusive, the water vapor absorption for corresponding values of *wm* given by curve (16) increased by 0.005 to take account of the selective absorption by the permanent gases of the atmosphere (**12**), we obtain the atmospheric transmission: a''_m, represented by curves (9) to (15). These curves give atmoshperic transmissions for dust-free air containing the amounts of precipitable water, *w*, indicated.

Finally, Linke (**13**) has defined atmospheric turbidity as the number of clear dry atmospheres, which together bring about the same extinction of radiation as the actual turbid moist atmosphere. He expresses it by the equation

$$T = \frac{1}{-m \log a'_m} \log \frac{I_o}{I_m} \qquad (5)$$

where a'_m is the atmospheric transmission for pure dry air through air mass *m*, and I_o and I_m are the solar radiation intensities at air masses 0 and *m*, respectively.

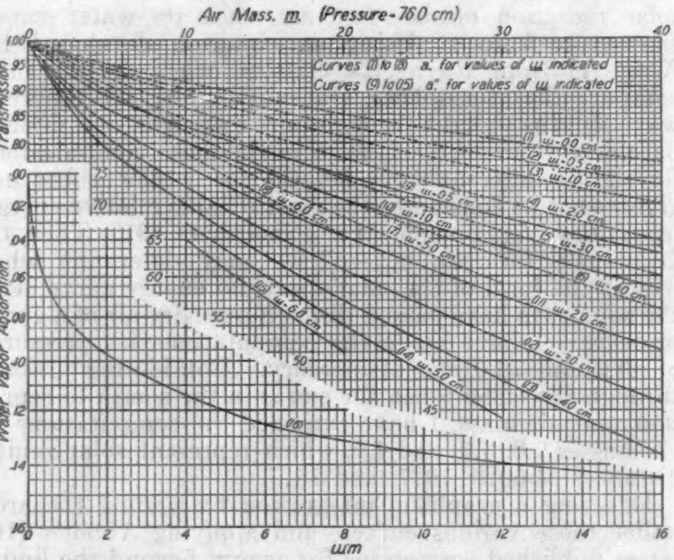

FIG. 1.—Atmospheric transmission of solar radiation through dust-free air: Curves (1) to (8) after scattering by dust-free air containing the quantities of water-vapor indicated by *w*; curves (9) to (15) after scattering and absorption by dust-free moist air containing the quantities of water-vapor indicated by *w*; curve (16) absorption by water-vapor for different values of the product *wm*

I have sought to compute the atmospheric turbidity due to dust alone, T_d, by substituting for a'_m in equation (5) the atmospheric transmission for dust-free moist air, a''_m, as given by curves (9) to (15), Figure 1.

A concrete example of the use of Figure 1 follows:

At Apia, Samoa, Thomson (**1**) divides the year into three seasons, as follows:

Dry season, May to August, inclusive.

Equinoctial season, March, April, September, October.

Wet season, November to February, inclusive.

Table 1 gives seasonal means of the meteorological elements with which we are particularly concerned.

TABLE 1.—*Seasonal means for Apia, Samoa*

Seasons	Barometer B (cm.)	Vapor pressure e (cm.)	$B-e$ (cm.)	w	Ratio, $\frac{B-e}{76.0}$	$\frac{I_{m=1}}{I_o}$	$\frac{I_{m=2}}{I_o}$	$\frac{I_{m=3}}{I_o}$
Dry	75.9	1.97	73.9	4.53	0.972	0.653	0.534	0.424
Equinoctial	75.8	2.07	73.7	4.76	.970	.637	.520	.441
Wet	75.6	2.10	73.5	4.83	.967	.674	.570	.475

From Table 1, Figure 1, and equation (5) the values of a'' and T_d given in Table 2 have been computed.

TABLE 2.—*Seasonal values of a'' and T_d for Apia, Samoa*

Seasons	$a''_{m=1}$	$a''_{m=2}$	$a''_{m=3}$	$T_{d(m=1)}$	$T_{d(m=2)}$	$T_{d(m=3)}$
Dry	0.686	0.554	0.460	1.14	1.06	1.11
Equinoctial	.680	.547	.451	1.18	1.08	1.03
Wet	.678	.545	.448	1.02	.926	.927

For extreme accuracy we should take for unit air mass the ratios $B\text{-}e/76.0$ given in Table 1. In the above example the value a'' is thereby increased about 0.002, which is inconsequential.

TABLE 3.—*Daily totals of solar radiation* (*direct+diffuse*) *received on a horizontal surface in the absence of clouds. Gr. cal. per cm².*

Latitude	Longitude	Jan. 21	Feb. 21	Mar. 21	Apr. 21	May 21	June 21	July 22	Aug. 22	Sept. 22	Oct. 20	Nov. 21	Dec. 21
90° N		....	....	....	....	818	896	745	....	....	....	....	....
60° N	7° E.-56° W.	....	204	376	582	735	771	692	556	361	193	....	....
	135-170° W.	....	229	413	629	793	794	726	564	368	208	....	....
56° N	7° W.	113	240	415	620	750	799	724	578	388	228	105	....
	135-170° W.	120	252	437	639	773	824	736	584	390	235	115	....
52° N	10° W.	171	307	460	641	763	795	735	589	415	287	164	119
	129° W.	174	314	472	656	782	827	754	650	460	304	171	123
48° N	60° W.	226	409	536	686	790	842	736	634	495	329	214	179
	4° W. and 124° W.	211	335	514	656	770	805	721	622	474	313	202	160
42° N	66-70° W.	298	444	592	727	802	811	743	639	514	390	285	256
	124° W.	278	404	582	723	807	830	770	674	522	391	270	233
36° N	6° W; 131-140° E.	365	459	612	716	732	743	716	653	546	433	341	317
30° N	65-77° W; 128-130° E.	404	466	629	722	768	732	692	633	516	424	386	360
	15° W and 117° W.	436	519	630	739	772	772	755	692	593	479	420	392
20° N	61-77° W.; 158° W.	492	610	692	736	751	790	736	706	663	587	487	466
10° N	61-69° W.; 17° W.-3° E.; 116° E.-80° W.	581	655	726	722	702	696	701	712	704	645	574	553
0°	7-12° E.; 48° W. and 170° E.; 55° E. and 159° W.	658	688	683	670	626	609	623	667	687	685	657	650
10° S	14° E.; 36°-38° W.; 72°-171° E.	723	738	681	605	538	513	555	630	695	712	718	720
20° S	46° W.; 47° E.-150° W.	742	708	646	548	473	442	473	563	661	721	787	788
	70° W.; 14° E.; 114°-122° E.	750	721	675	586	496	497	506	603	680	732	816	766
30° S	17° E.; 116° E.; 110° W.	858	751	626	505	386	354	396	514	642	712	850	893
36° S	62° W.; 18° E.; 115° E.; 78° W.	818	710	577	440	327	282	334	454	591	731	830	867
42° S	73° W.; 147° E.	806	704	537	383	260	219	263	387	575	735	848	888
48° S	70° E.; 168° E.	807	655	507	322	202	161	203	376	510	684	829	900
52° S	58° W.	830	652	452	293	100	113	162	299	462	663	830	898
56° S	37-70° W.	807	637	411	234	110	....	113	238	427	652	808	919
60° S	45° W.	838	631	386	203	....	....	....	219	407	647	846	891

The values of T_d less than unity during the wet season, while partly due to the fact that frequent showers keep the air nearly free from dust (**1**), are no doubt principally due to the shallowness of the southeast trades at this season (**1**), and, in consequence, an overestimate of the value of *w*.

Determinations of T_d from observations on individual days at sea give great variations in its value. From all the observations available I have been led to use the value 1.15 except near the west coast of Africa, where Linke's observations indicate a very considerable increase in the atmospheric dustiness, and during the wet season in the tropics, when the value ±0.0 was employed. It is to be noted that T_d usually decreases in value with increase in air mass.

Atmospheric transmissions have been computed from Figure 1 for the latitudes indicated in Table 3 and corrected by T_d. Estimates of the water vapor content of the atmosphere have been based on monthly means of temperature and relative humidity for about 140 stations, obtained principally from the various volumes of the Pilot, published by the hydrographic department, British Admiralty, and from meteorological summaries prepared by Reed (**14**). Vapor pressure values thus

obtained are undoubtedly more accurate for island than for continental stations, on account of the relatively small temperature variations at sea.

The stations selected are distributed in latitude from Treurenberg, Spitzbergen, 79° 55′ N., to Laurie Island, South Orkneys, 60° 44′ S. They have been grouped so as to give the vapor pressures at the latitudes indicated in Table 3. In the Tropics there is little variation in vapor pressure with longitude. In temperate regions the west shores of oceans usually show higher humidities than east shores, especially in north latitudes, probably on account of the warm west-shore ocean currents. The vapor pressures have been grouped so as to bring out these differences, which are reflected in the radiation intensities.

Atmospheric transmissions give solar radiation intensities on the assumption that the value of the solar constant is 1.0. They have been computed for each hour angle of the sun from noon for the dates indicated in Table 3, which have been selected so as to include the dates of greatest north and south declination of the sun, dates when its declination is ±0, and dates in July, August, October, and November, which have the same solar declination as the 21st of May, April, February, and January, respectively. They have been multiplied by the sine of the sun's altitude at each hour from noon, apparent time, to obtain the relative intensity of the solar radiation on a horizontal surface, and increased by a proportional part, depending upon the water-vapor content of the atmosphere and the solar altitude, so as to include in the total the diffuse solar radiation from the sky (**15**). These final values have then been plotted against intensities as ordinates and hour angles as abscissas and a smooth curve drawn through them from the value at noon to 0 at the time of sunrise or sunset. A graphical integration is effected by finding the area under this curve. The area is then multiplied by twice the solar constant divided by the square of the earth's relative solar distance on the dates indicated for each month. The result given in Table 3 is the average radiation to be expected on the dates indicated with cloudless sky conditions, expressed in gram-calories per cm.² per day. It is to be noted that in both hemispheres the daily totals average higher in the spring months than in the fall.

Figure 2 shows graphically the variations with latitude in the total solar radiation received over the oceans on the 21st of June. No radiation is then received south of the Antarctic Circle. There is in general a gradual increase in the daily total until latitude 48° N. is reached, although the changes are slight from latitude 42° N. to the pole. Increasing length of day and decreasing water-vapor content of the atmosphere unite to give maximum values at high north latitudes, in spite of the low altitude of the sun even at midday. The higher values on the east shores of oceans than on the west is well brought out in the daily totals for latitude 20° S. and 30° N. At latitude 48° N. the conditions are reversed over the Atlantic Ocean on account of the cold Labrador current on the west shore. On December 21 (fig. 3) daily maxima are reached at about latitude 48° S. with little change to latitude 60° S. In general, there is less variation in the daily totals with longitude in the southern hemisphere than in the northern.

From the same sources as for temperature and humidity, and for about the same number of stations, monthly means of cloudiness have been obtained. Ångström (**16**) and others have determined an approximate relation between daily totals of solar radiation and both the duration of sunshine and the average cloudiness. The latter relation is not so well determined as the former, since the relation with cloudiness seems to vary with the percentage of cloudiness (**17**) and perhaps also with solar altitude (**16**). I have determined average daily totals of solar radiation, Q, from the totals with a cloudless sky, Q_o, by the equation

$$Q = Q_o(0.29 + 0.71[1.0 - C]) \qquad (6)$$

where C is the proportion of the sky covered by clouds, and Q_o is taken from Table 3. The results are given in Table 4, "Average daily totals of solar radiation received on a horizontal surface."

TABLE 4.—*Average daily totals of solar radiation received on a horizontal surface (direct + diffuse), gr. cal. per cm.²*

Latitude	Longitude	Jan. 21	Feb. 21	Mar. 21	Apr. 21	May 21	June 21	July 22	Aug. 22	Sept. 22	Oct. 20	Nov. 21	Dec. 21
90° N		----	----	----	----	356	387	322	----	----	----	----	----
60° N	7° E.–56° W	----	101	200	318	406	421	372	287	189	92	----	----
	135–170° W	----	141	240	316	399	365	345	244	167	102	----	----
56° N	7° W	50	109	206	308	372	389	328	229	182	107	49	----
	135–170° W	66	127	235	321	389	356	318	231	183	110	54	----
52° N	10° W	74	146	228	331	378	383	354	288	212	140	80	54
	129° W	81	147	204	283	366	357	326	304	199	131	74	53
48° N	60° W	114	206	270	345	397	424	422	364	284	165	108	78
	4° W. and 124° W	94	157	259	339	414	405	388	335	255	153	90	71
42° N	66–70° W	139	223	327	402	449	477	421	376	317	235	153	120
	124° W	148	246	313	435	486	524	442	382	318	233	151	129
36° N	6° W	225	280	378	472	498	522	538	496	371	285	225	196
	131–140° E	215	260	334	380	389	321	360	375	275	242	208	196
30° N	65–77° W	212	247	365	420	462	441	432	399	326	259	244	197
	15° W. and 117° W	306	364	415	482	476	482	449	437	420	340	301	281
	128–130° E	206	225	303	353	376	332	378	372	296	249	216	189
20° N	61–77° W.; 158° W	335	420	466	475	452	493	464	450	428	379	324	307
10° N	61–69° W	371	404	437	440	383	404	412	424	409	384	350	345
	17° W.–3° E	424	483	556	527	477	414	422	439	444	453	403	392
	116° E.–80° W	329	385	427	394	363	340	348	348	359	338	321	314
0°	7–12° E	345	361	348	328	297	280	269	283	326	349	344	336
	48° W. and 170° E	373	385	411	432	448	428	433	511	531	520	480	382
	55° E. and 159° W	340	395	402	403	355	337	366	397	419	408	363	355
10° S	14° E; 36–38° W	476	471	421	356	309	294	350	411	458	469	453	404
	72–171° E	415	455	454	406	381	360	397	451	483	444	432	439
20° S	46° W; 47° E. and 150° W	453	426	389	353	305	285	308	363	417	465	508	486
	70° W	564	567	508	441	337	321	326	367	415	447	555	548
	14° E	345	332	335	295	278	285	269	303	323	348	399	342
	114–122° E	575	526	536	486	408	405	427	533	613	649	712	614
30° S	17° E. and 116° E	657	553	475	343	254	208	255	324	423	535	585	627
	110° W	541	454	359	290	222	183	222	288	360	477	488	576
36° S	62° W.; 18° E	597	528	421	306	209	170	208	286	385	477	559	621
	115° E.; 78° W	510	422	335	243	174	140	173	238	323	404	471	529
42° S	73° W.; 147° E	492	404	308	206	140	118	141	208	289	395	456	510
48° S	70° E.; 168° E	423	358	291	185	116	92	117	216	293	368	429	464
52° S	58° W	412	319	227	151	80	52	78	155	232	333	406	439
56° S	37–70° W	395	320	198	113	55	----	58	128	233	319	401	449
60° S	45° W	303	228	139	73	----	----	----	95	176	234	305	322

The variations in cloudiness with longitude cause much greater variations in the daily totals of radiation than do the variations in absolute humidity. For this reason an increased number of groupings along the different parallels of latitude becomes necessary. These variations become clearly apparent when the daily radiation totals are charted as in Figures 4 to 7, inclusive, for December 21, June 21, March 21, and September 22.

The monthly mean cloudiness on the Gilbert Islands is so much less than at other islands near the equator that one may well ask if topographic features on islands may not in some cases markedly modify the cloudiness, so that it is not representative of the general cloudiness of its locality. Sufficient data was not at hand while this paper was in preparation to make a study of the topography of the different islands. It therefore seemed best to base the computations on the data as published.

A few solar radiation records are available for checking the computed daily totals of solar radiation of Tables 3 and 4. Reference has already been made to measurements of the intensity of direct solar radiation at certain marine stations, and their use in computations of the value of T_d. It has also been found that atmospheric

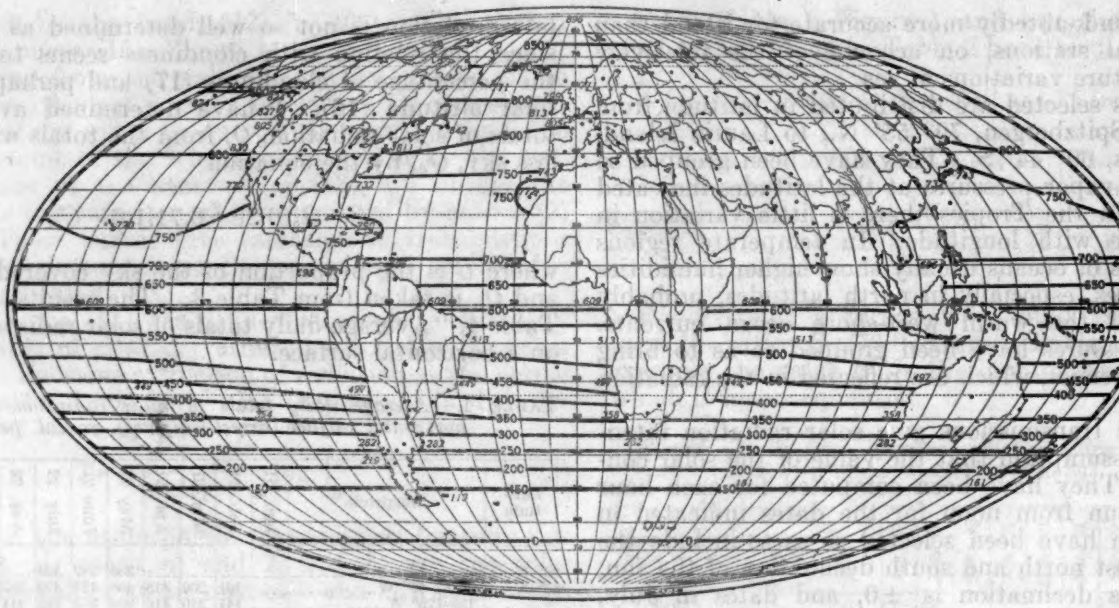

Fig. 2.—Isopleths of total solar radiation (direct plus diffuse) on June 21 with cloudless sky
(Gram-calories per day per cm.² of horizontal surface)

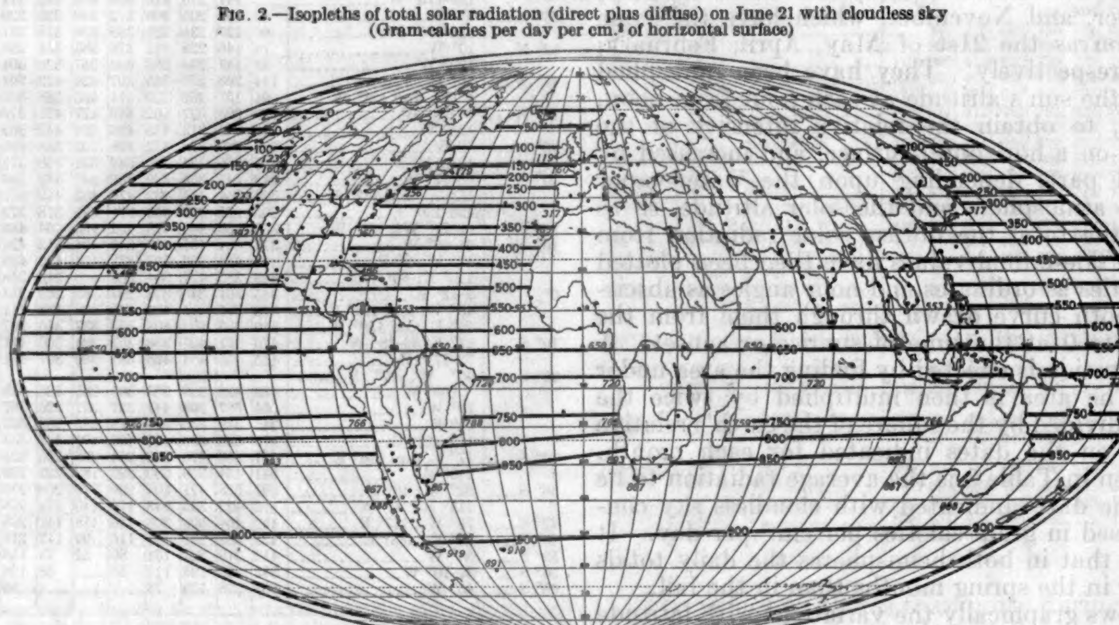

Fig. 3.—Isopleths of total solar radiation (direct plus diffuse) on December 21 with cloudless sky
(Gram-calories per day per cm.² of horizontal surface)

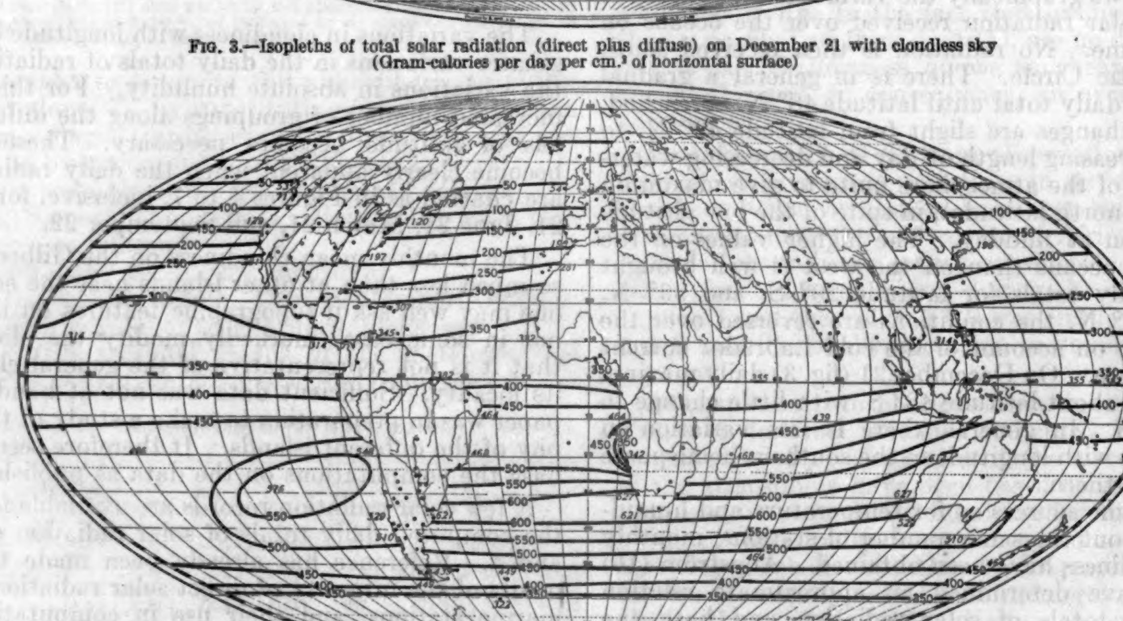

Fig. 4.—Isopleths of total solar radiation (direct plus diffuse) on December 21 with average cloudiness
(Gram-calories per day per cm.² of horizontal surface)

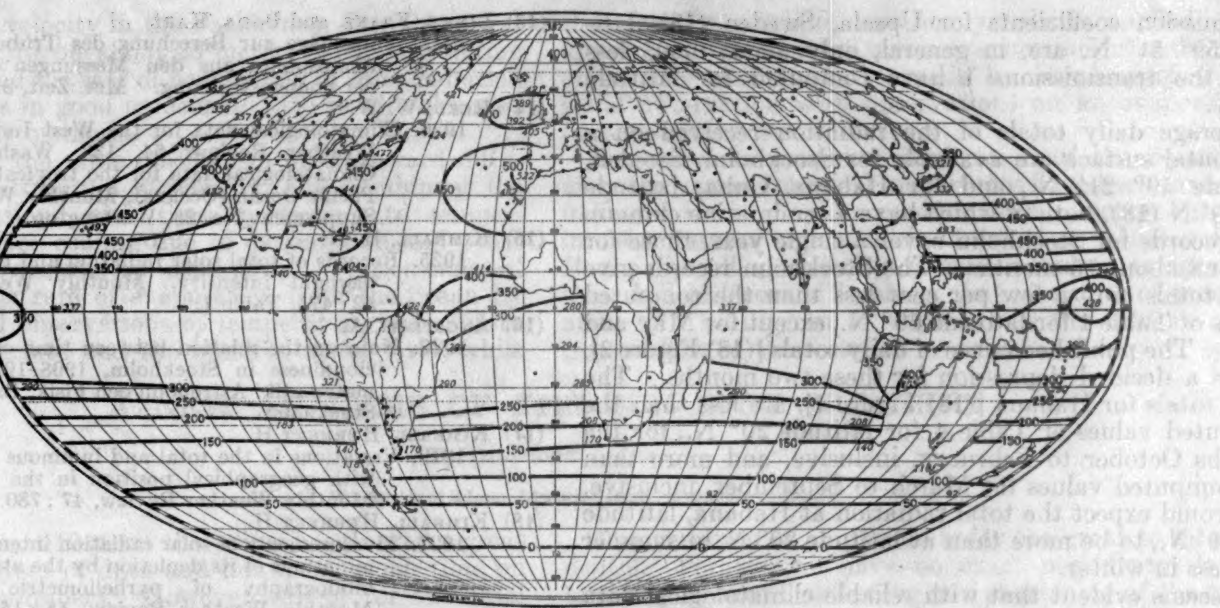

FIG. 5.—Isopleths of total solar radiation (direct plus diffuse) on June 21 with average cloudiness
(Gram-calories per day per cm.² of horizontal surface)

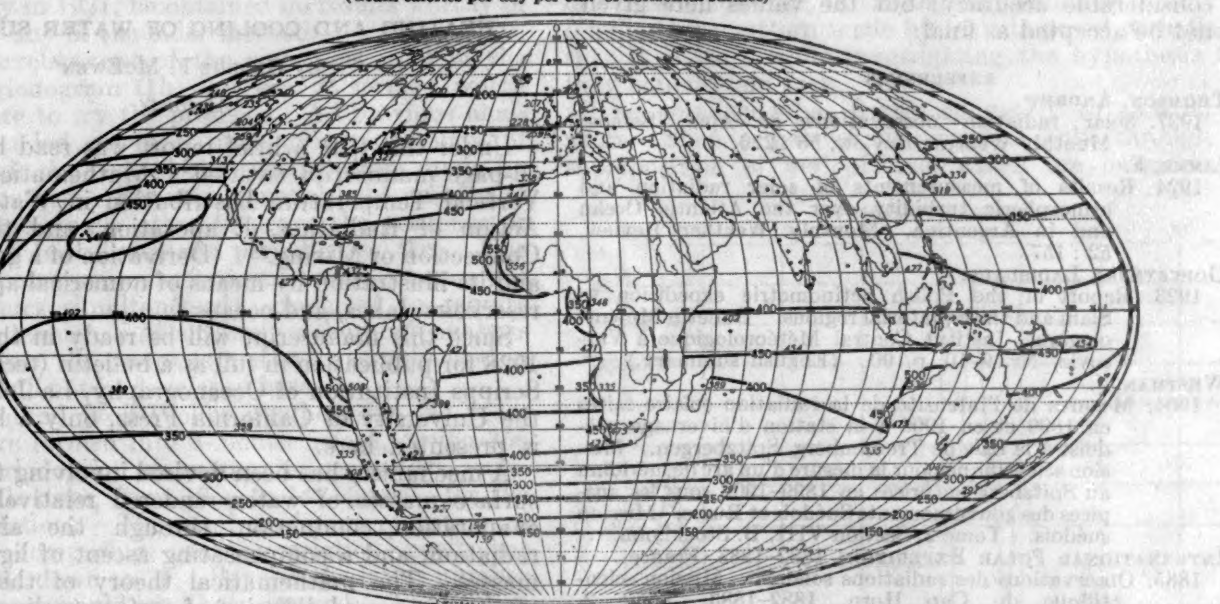

FIG. 6.—Isopleths of total solar radiation (direct plus diffuse) on March 21 with average cloudiness
(Gram-calories per day per cm.² of horizontal surface)

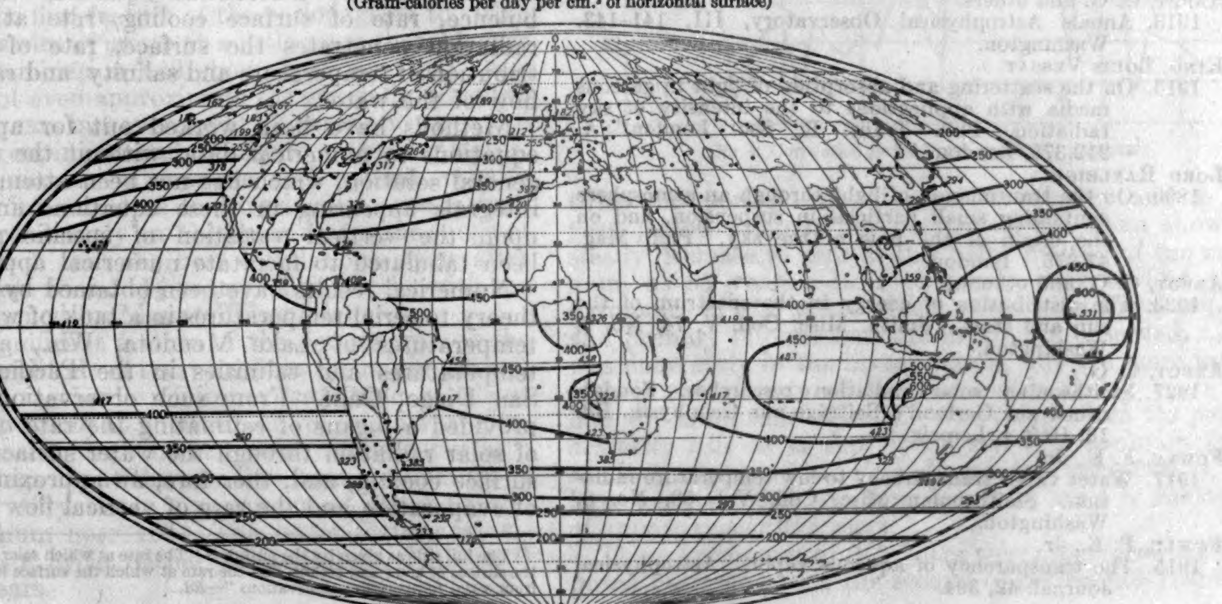

FIG. 7.—Isopleths of total solar radiation (direct plus diffuse) on September 22 with average cloudiness
(Gram-calories per day per cm.² of horizontal surface)

transmission coefficients for Upsala, Sweden (**18**), latitude 59° 51′ N. are, in general, only about 0.005 less than the transmissions I have computed for latitude 60° N.

Average daily totals of the radiation received on a horizontal surface are available for Stockholm, Sweden, latitude 59° 21′ N., and for Habana, Cuba, latitude 23° 09′ N (**18**), both of which have a semimarine climate. The records for Stockholm cover a single year, those for Habana about 15 months. The Stockholm records give daily totals only a few per cent less than the computed values of Table 4 for latitude 60° N., except for May and June. The published curve of daily totals [(**18**) Figure 2], shows a decided depression for these two months. The daily totals for Habana [(**18**) Figure 1], are less than the computed values of Table 4 for latitude 20° N., for the months October to February, inclusive, and more than the computed values for March to September, inclusive. We would expect the total radiation at Habana, latitude 23° 09′ N., to be more than at latitude 20° N. in summer and less in winter.

It seems evident that with reliable climatological data the radiation intensity over the oceans may be computed with considerable accuracy; but the values here given must not be accepted as final.

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HEATING AND COOLING OF WATER SURFACES[1]

By GEORGE F. MCEWEN

(*Abstract*)

Under this title a brief report was read based upon a 50-page manuscript entitled: "Mathematical Theory of Vertical Temperature Distribution in Water under the Action of Radiation, Evaporation, and the Resulting Convection or Mixing." (Derivation of a general theory, and its illustration by means of numerical applications to reservoirs, lakes, and oceans.)

Since this manuscript will be ready in the summer of 1928 for publication in full as a bulletin (technical) of the Scripps Institution of Oceanography, La Jolla, Calif., by the University of California Press, only a brief abstract is presented here.

A mechanism has been devised involving the sinking of surface masses of water rendered relatively heavy, the evaporation, conduction through the air, and back radiation, and a compensating ascent of lighter, warmer masses. The mathematical theory of this mechanism of the downward diffusion of surface cooling led to a pair of simultaneous differential equations involving turbulence, rate of surface cooling, rate at which solar radiation penetrates the surface, rate of vertical distribution of temperature and salinity, and rate of vertical flow of the water.

Methods have been worked out for applying these equations to numerical data, without the need of their general solution, which has not been attempted. Three integrals appearing in these equations and depending upon the vertical variation of specific gravity have been tabulated to facilitate numerical applications.

Numerical results have been obtained by applying the theory to serial temperatures in a tank of water, to serial temperatures of Lake Mendota, Wis., and to serial temperatures and salinities in the Pacific Ocean near San Diego, Calif. From such observations the theory provided a means of estimating the rate of penetration of solar radiation through the water surface, the rate of surface cooling, and, therefore, an approximate estimate of evaporation and the rate of vertical flow of the water.

[1] The full title as given by the author is "The rate at which solar radiation penetrates the surface of lakes and oceans, and the rate at which the surface loses heat as deduced from serial temperature-observations."—*Ed.*

The upwelling velocity in the Pacific near San Diego was thus estimated to be about 25 meters per month during the summer, and the rate of penetration of solar radiation thus found was in good agreement with results obtained by independent methods.

By applying the same mechanism of downward diffusion to the distribution of salinity, and combining the resulting equations with those pertaining to temperature, the surface cooling due to evaporation and other causes can be estimated separately. This means of determining the rate of evaporation from the ocean by means of serial observations of temperature and salinity between the surface and the hundred-meter level, while theoretically possible, has not yet been applied. An approximate estimate of ocean evaporation from the rate of surface cooling can be made by supplementing the serial observation with observations on an evaporating pan containing sea water.

Numerical or graphical integration of the equations after the various physical magnitudes have been found as indicated above should reproduce the subsequent changes in temperatures and salinities from their initial values. If the upwelling velocity is not included, integration should yield "normal" values; that is, values of temperature and salinity to be expected in the absence of a general flow of the water.

A NEW ANALYSIS OF THE SUN SPOT NUMBERS

By DINSMORE ALTER

[University of Kansas, Lawrence, Kans., November 16, 1928]

During the past 10 years the writer has worked a great deal with analyses of data and has spent much time on the sun spot numbers. However, except for one brief paper on the 11-year means (**1a**), read before the Astronomical Society in 1921, he obtained no results worthy of publication by any of the older methods.

With the development of the equations used in the correlation periodogram (**1b**) last year it seemed worth while once more to try the problem. All previous analyses had depended on repetitions of a sine curve of assumed period, the best of these being those made by the Schuster method. For such a method the number of data was far too small, either to prove the existence or nonexistence of fairly constant periodicities (**1c**). The new method, however, using not only such a curve but all its harmonics simultaneously, promised to require less data for a decision. Accordingly a thorough analysis was made. Since the complete method was published in this journal it will not be developed here.

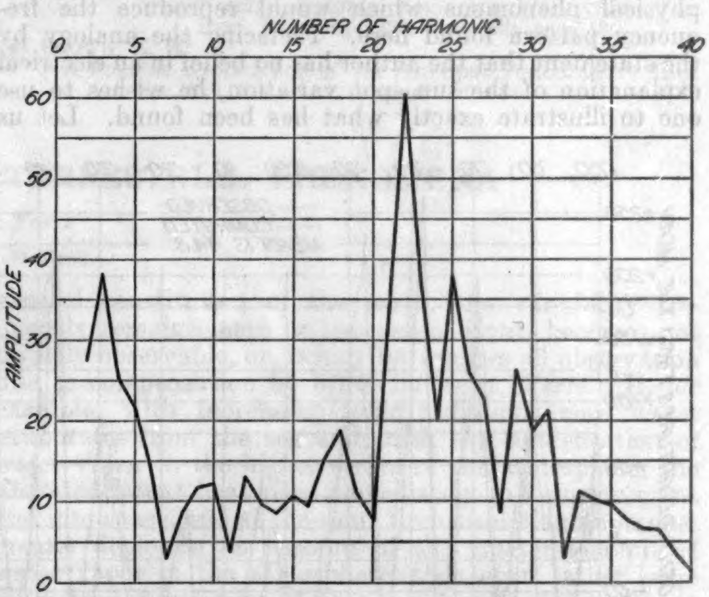
The unsmoothed Wolf-Wolfer numbers for the years 1749–1926 were formed into 6-month means, giving 356 data. The periodogram was computed using logs, varying by 6-month steps, from 12½ to 142½ years for the separate correlations. The number of pairs of data used therefore, in computing each correlation coefficient ranged from 331 down to 71. Beyond the latter number but little accuracy would have been secured. The periodogram is reproduced as Figure 1.

Naturally the first feature of the periodogram to strike the eye is the series of crests at a little more than 11-year intervals. Examination will show, however, that their intervals do not even approximate the generally accepted value of 11⅛ years but average 11.37 years and are quite consistent in grouping around this figure. In other words, although the number of maxima and minima usually considered by investigators to be principal ones is such as to give approximately an 11⅛-year mean, the shape of the curve is such that the best correlations occur after intervals of more than 11⅛ years. This checks with the long value assumed by Mount Wilson.

The next significant feature of the periodogram is the variation in amplitude of its swing between minimum and maximum. It reaches a minimum amplitude at about 33 years, a maximum at about 65 or 70, and a very pronounced minimum at about 126 years. The curve as a whole also swings about the zero line from a minimum at approximately 40 years to a maximum at about 85 and another minimum near 126. The latter feature is evidently due to a cycle (either accidental or significant) of about 85 years.

The variation in amplitude is far too great to be accidental. Perhaps we have no exact periodicity, but a tendency toward lengthening and shortening of the cycle such tendencies persisting through considerable number of years. However, the changes resemble so closely the familiar best pattern made by superimposed periodicities that it is worthwhile investigating the hypothesis that they actually are such.

The amplitude has decreased nearly to zero at 126 years. Such a pattern could come only through the superposition of periodicities, which are harmonics of



No. 1. Correlation periodogram of sun spot numbers

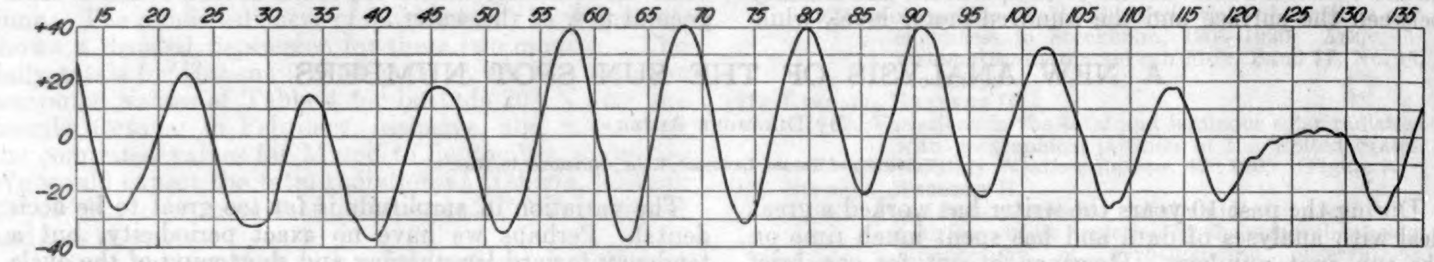
twice this period. If only such a primary and a 126-year period existed, the pattern would have shown a steady decrease to zero at this point instead of the maximum at 85 years. It is obviously easy to find three harmonics of 252 years which would give the secondary and primary minima and the maximum observed. This was done early in the investigation, but the more logical plan is to compute all the harmonics of 252 years and find the amplitude of each. *One thing which the pattern definitely tells us is that, if the sun spot variation is the result of superposition of fairly constant periodicities, any large ones of length less than a century must be harmonics of approximately 252 years.*

These harmonics of 252 years were, therefore, all computed beginning with the second of period 126 years and

ending with the fortieth of period 6.3 years. The data are reproduced as Figure 2, where the ordinates are the amplitudes, expressed as percentages of the mean sunspot number. They vary in amplitude from practically zero for the fortieth to 61 per cent for the twenty-second. The distribution of large amplitudes does not follow, in the least, that expected by the error law. Since the basic period is 252 years, instead of the 178 for which we have data, adjoining periods are not entirely independent, though nearly so. The amplitudes are all greater than 20 per cent through the fifth, then all are less than this value (with the exception of the eighteenth far less) through the twentieth. From here through the thirty-first with two exceptions all are greater than 20 per cent and from there on all are far less. Whether we have exact periodicities or not, such a distribution can not be accidental.

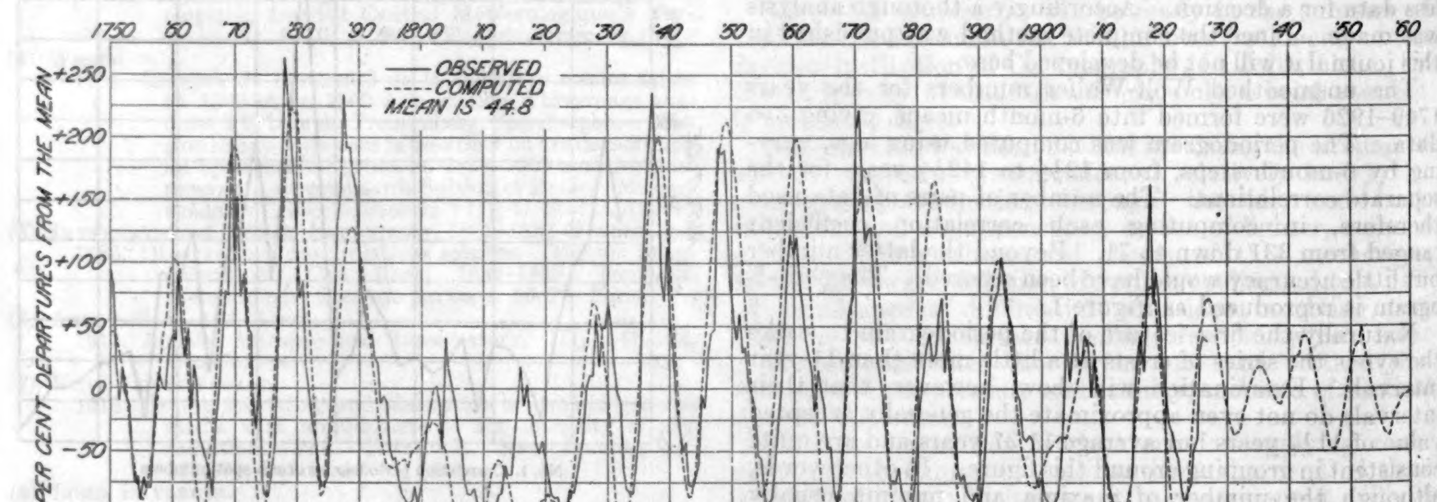
It will be interesting to see whether we have any known physical phenomena which would reproduce the frequency pattern found here. Prefacing the analogy by the statement that the author has no belief in an electrical explanation of the sun spot variation, he wishes to use one to illustrate exactly what has been found. Let us construct a coil of such capacity and inductance that it is tuned to oscillate over a rather broad band of frequencies, say between one-twenty-first and one-thirty-first of a second. Let us impose on this coil an electrical impulse each second, of such nature that the harmonics decrease in amplitude as they decrease in length of period. Such impulses are easy to produce. The longer harmonics, having great amplitude, will be found as forced surges in the coil, despite its damping qualities. Soon the amplitude of these surges will decrease to negligible amounts and none of large amplitude will be found until we reach the band for which the coil is tuned. Here again we will find surges of large amplitude and, when the band is past, the amplitudes will rapidly decrease almost to zero. Periodicities other than harmonics of the primary surge will not be found. We have then an actual case of frequency distribution similar to that *apparently* found in the sun spot data.

All harmonics of amplitude greater than 20 per cent have been added together to reproduce the past history of the variations and to extrapolate for test purposes. Of course, inclusion of smaller terms would have increased the accuracy of the representation of the past as closely as might be desired. Such a gain would have had little advantage, for, if it should prove to be true that the large periodicities chosen are substantially real, they must give enough of a correlation between ephemeris and future observation to demonstrate their validity without the use of smaller ones, even though such might also be real. If these be real, or approximately so, accurate prediction by means of all possible periodicities would belong to later work. Figure 3 gives this representation.



No. 2. Amplitudes of sun spot terms

Fortunately, for our test purposes, the ephemeris shows, in the immediate future, very small oscillations similar to those at the beginning of the last century, except that now, instead of being superposed on a minimum of the general progression they oscillate about the mean. *The author does not predict that the ephemeris will be followed.* He merely claims that *if* approximately constant periodicities do exist they must be the series found. His own opinion regarding such will be based on the observations of the next 10 or 15 years. If there are no very pronounced maxima or minima, he will accept them as real, otherwise believe the phenomenon to be non-periodic.



No. 3. Sun spot representation, using 126, 84, 68 . . . terms

The inaccuracy of the first three-quarters of a century of data must have to some extent vitiated amplitudes and

phases of such periods. It is believed, therefore, that beyond the possible demonstration of their existence, little can be done to secure accurate ephemerides until at least another half century of data are secured.

The writer's studies are primarily concerned with probabilities of observed departures from the error law, not with physical explanations of results found. However, he wishes to suggest very tentatively an explanation. Various writers have, during the past 30 years, urged the planetary tides as an explanation of sun spots. Most noteworthy of these is an early paper by E. W. Brown (2), using the tides of Jupiter and Saturn. With these he gave an excellent representation of the past epochs of maxima and minima. An ephemeris computed for the 30 years since his paper was published is almost perfect in locating epochs.

The tides have always seemed an impossible explanation on account of their feebleness in comparison with the sun's gravitational field. However, the recent study of radiation pressure and of the solar spectrum have proved an almost perfect balance of forces in the solar atmosphere. This being the case small tidal effects may possibly produce large results.

To test this possibility, an examination was made to see whether there is any unique relationship of the planetary periods to the assumed primary impulse period of 252 years. Exact multiples and half multiples of their periods must be considered, since, except for eccentricity effects, the latter give the same tidal effects as the former. So far as probabilities are concerned the deviations of the nearest multiples from a common multiple may be as great as 25 per cent of a planet's period. If there is much less average deviation than half this amount, there is a straw of evidence in favor of the hypothesis.

Planet	Period	Multiple factor	Product	Per cent deviation in terms of planet's period
Jupiter	11.862	21	249.10	4.8
Saturn	29.458	8½	250.39	2.4
Uranus	84.015	3	252.04	2.8
Neptune	164.788	1½	247.16	1.5
Mean			249.67	

In every case the percentage deviation is found to be very small. This 250-year multiple is the only one to be found for these planets. The uncertainty of our 252-year period is greater than the difference from this mean. Though one would not wish to claim anything for the coincidence, it certainly is one to be borne in mind.

The writer wishes to acknowledge the aid of a grant from the research committee of the University of Kansas, under which he engaged Mr. James Edson to do the majority of the computing.

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THE PERIODS OF SOLAR AND TERRESTRIAL PHENOMENA [1]

By Prof. H. FRITZ

[Translated by W. W. Reed]

In the past decades there have appeared numerous papers on the periodic phenomena whose changes show more or less marked agreement with the periodic change in solar activity as it is most readily traceable in the changing frequency of sun spots. A similar change together with apparent relation, unexplainable or not directly explainable, between processes on the earth and processes on the sun can not be astonishing since the manifestation of energy, all animate or inamimate nature on the earth, is subject to energy radiated from the sun to the planet. The earth provides the matter, the sun supplies the energy. In contrast to the supply of energy from the sun, that from the interior of the earth, that radiated to the earth from the stars, and that reflected to the earth from the moon fade into nothingness. The moon acts most effectively through the attraction exerted on the earth and its constituent parts.

Inevitably every variation in solar activity must be reflected in terrestrial processes, although because of the general constitution of the earth, the variability frequently remains more or less out of sight, becomes not directly observable, or, it may be, escapes all observation due to compensation by other forces or effects. If, for example, with increasing solar radiation more water evaporates from the sea and, with the condensation of water vapor in the higher strata of the atmosphere, the liberated latent heat rises immediately to higher regions and into space, and at the same time insolation undergoes greater depletion on account of the greater amount of water vapor in the atmosphere, then even rather large differences in radiation of heat by the sun will be without influence on our measuring instruments and will no longer be shown by them. This single example will serve as well as many.

If there exist in the different phenomena of the earth periodic changes dependent on solar activity, then they can not be limited to a few decades; they must be present, on the contrary, in the oldest observations available at the present. In the contrary case one would be permitted to apply not entirely without reason the conventional word "accident."

Unfortunately, research extending far into the past is possible only in a restricted way; most of the useful data relative to the different kinds of phenomena are very recent.

Because of its definitely decided periodicity, its uniqueness, and its awesomeness, one terrestrial phenomenon can

[1] Astronomers and meteorologists appear to be but little aware of the general intrinsic value of the work done by Prof. H. Fritz which culminated in *Die Perioden solarer und terrestricher Erscheinungen,* published in *Vierteljahrschrift der Naturforschenden Gesellschaft in Zurich, Heft* 1, 1893.

As this publication is not accessible to many American students its translation and republication in the MONTHLY WEATHER REVIEW seems to be particularly appropriate at the present time when various authorities are seeking to establish indirect correlations between solar activity and features of weather sequence on the earth. It is a pleasure, therefore, to commend to the careful attention of the readers of the REVIEW Mr. Reed's translation of Professor Fritz's paper, more particularly with reference to the data and final tables of the epochs of the maxima of the 11-year cycle, which, with the modern tables of Wolfer, cover a total range of 17 and 34 years. The author's discussion of long periods and the possible causes of sun spots must stand on its own merits.—*C. F. Marvin.*

be followed in observations going far backward through the years. This phenomenon is the aurora. On account of the decidedly periodic change in frequency, extent, and grandeur shown by the aurora and the fact that everyone's attention was drawn to the "northern lights," records were not to be omitted in the earliest works on history and especially could they not be overlooked in the chronicles. (For "southern lights" we have no record of phenomena earlier than those observed in Chile in the spring of the year 1640.) Even if not a few of the old records leave the reader in doubt whether the reference is to aurora, comet, or other fire phenomenon, there still remains such a large number of certain records of auroras that the epochs of the periods are very definitely manifest, especially in the regions in which the phenomenon sometimes fails to appear for a decade and only the most significant instances become noticeable.

Since the vintage is decidedly periodic in amount and since from olden times special mention has been made of it (and of hail which is damaging to this and all other produce of the fields), the related information, although it is scant, may be used with the auroral phenomena of earlier times to establish agreement in their periodicity. For good reasons this can not be done at all, or at best only very imperfectly, with other phenomena for times so far removed in the past.

Table 1 contains the old sun spot observations from the year 188 up to the exact detection of the spots by Fabricius in the year 1610. The data are taken from the Chinese observations, supplemented in part by records from Europe. The sources of data are given in detail in Wolf's *Mitteilungen über die Sonnenflecken* and his *Astronomische Mitteilungen* including 80 numbers to date (1893).

The second and third columns of Table 1 show the frequency of the months and days with visible spots; the fourth column gives the dates of the probable maxima of the short period.

Table 2 gives the year and the annual number of the old auroral observations between the years 194 and 1635 according to the phenomena recorded in the *Polarlichtkatalog* and its supplements.[2] Since these relate altogether to middle and southern Europe, the observations of Tycho de Brahe on the island of Hven (1582–1591) are added in brackets. The last column contains the dates of the probable maxima of the short period.

Tables 3 and 4 give the favorable vintage years mentioned in the old writings relating to Germany, Austria, and Switzerland, and the years that have become noted on account of heavy fall of hail. In both cases the years that were most conspicuous are printed in bold-faced type and the dates of the rather probable maxima of the short period are added in the last column.

In Table 5 there are placed side by side the maxima of the short period for the four different phenomena as given in the preceding tables, also the mean date of the maximum as determined from the preceding columns, the interval in periods of about 11 years, and the epoch of the period of 55.3 years, calculated from the table. Table 5*a* [3] is a continuation of Table 5.

[2] See *Verzeichnis beobachteter Polarlichter.* H. Fritz. Wien. 1873.
[3] Given separately on account of different form.—Translator.

TABLE 1.—*Sun spot phenomena* [1]

Year	Number of months	Number of days	Year of probable maximum	Year	Number of months	Number of days	Year of probable maximum	Year	Number of months	Number of days	Year of probable maximum	Year	Number of months	Number of days	Year of probable maximum	Year	Number of months	Number of days	Year of probable maximum
188	1	1	188	389	1	1		842	1	1		1136	2	2		1376	1	1	
299	1	1		395	1	1		864	1		864	1137	2	2		1381	1	5	
300	1			396	1	1	398	865	1			1138	2	2	1138	1382	1	1	1382
301	2	3	301	400	1	2		874	1		874	1139	2			1383	1	1	
302	1	1		409	1	1	409					1145	1	1	1145				
304	1	1						974	2	2	974	1160	1		1160	1511			1511
307	1	1		499	1	1		1005	1	1	1005	1185	3	16	1185	1529			1529
311	1	1	311	501	1		501					1186	2	2		1547	1	3	1549
321	2	2	321	502	2	2		1077	1	16		1193			1193				
322	2	2		509	1			1078	2	20	1078	1200	3	12		1588	[7] 1	1	
342	2	2	342	510	1		511	1079	2	12		1201	2	32		1590	[8] 1	3	1591
354	1	2	354	513	2			1089	1	1	1089	1202	1	1	1202	1593	[9] 1	1	
355	1	2		535	[2] 14		535	1096	1	1	1096	1204	1	1		1596	[10] 1	1	
359	2	2		577	1	1	577	1103	1	1		1205	2	14		1607	[11] 1	1	1602
360	1		360	580	1			1104	1	1	1104	1238	1	1	1238	1609	[12] 1	1	
361	1			626	[3] 8		626	1105	1			1276	1	1	1276	1616	[13] 1	1	1617
369	1	1		778	[4] 1	1	778	1112	1	2	1112					1617	1		
370	1	2		807		[5] 7	807	1118	2	2		1370	3	19		1618	[13] 1	3	
372	1	1	372	826	1	1	828	1120	3	3	1120	1371	3	46		1624	[13] 2	2	
373	3	3		832	1	2		1122	1	1		1372	4	4	1372	1626			
374	2	3		837	1	2		1123	1	1		1373	1	1		1638	[13] 1	1	
375	1	1		840	[6] 4	90	840	1129	3	3		1374	1	5					
388	1	1	388	841	1	1		1131	1	3	1130	1375	2	2					

[1] According to Wolf the first exactly determined spot maximum was that of 1626. The most conspicuous maxima were those of 1727.5, 1778.4, 1788.1, 1837.2, and 1870.1.
[2] 535–536, diminished brightness of the sun.
[3] Sun partially darkened.
[4] After Lycosthenes.
[5] After Eginhardt.
[6] (Humboldt, Kosmos.)
[7] After Secchi.
[8] Reported by the ship Richard of Arundell.
[9] After Henneberg.
[10] After Fausten.
[11] Observed by Keppler.
[12] After Henry Hudson.
[13] Observed in China.

TABLE 2.—*Aurora borealis* [1]

Year	Times observed	Year of probable maximum	Year	Times observed	Year of probable maximum	Year	Times observed	Year of probable maximum	Year	Times observed	Year of probable maximum	Year	Times observed	Year of probable maximum	Year	Times observed	Year of probable maximum
194	(2)	194	673			940		940	1153		1151	1403		1401	1574	3	
394			676		676	944			1157		(?)	1432			1575	2	
397		397	677	[8] 10		945			1166			1437		1435	1576	3	
400			710		710	957		957	1173			1460			1580	15	1580
434		434	727		727	970		970	1174			1461		1462	1581	13	
450			740			971			1175			1465			1582	[17] 6(2)	
453		453	741			978			1177	2	1177	1517			1583	9(18)	
454			742		742	979	[12] 2	979	1179			1518		1518	1584	4(14)	
479			743			992	[13] 3		1187		1187	1521			1585	3 (4)	
480			745			993	[12] 2	993	1189			1524			1586	3 (5)	
488			765		765	999			1192			1526			1587	4 (3)	
502	(3)	502	773			1000			1193	3	1193	1527			1588	5 (5)	
504			776		776	1002		1002	1194			1529	[13] 3	1529	1589	(5)	
512		512	778			1003			1195			1531	2		1590	4(15)	1590
538		540	786		786	1014		1014	1200			1532	(16)		1591	4 (4)	
541	(4)		800			1069		1069	1203	3	1203	1533			1592	3	
551			803			1084		1084	1204	(8)		1536			1593	8	
555		555	806		806	1093			1226		1226	1538	(16)	1538	1599	3	
556			807	(9)		1094			1243			1539			1603	4	
560			808	(9)		1095	(12)		1245		1247	1540			1604	6	1604
563			827		827	1096	2		1251			1541			1605	4	
564			828			1097	(3)	1097	1262			1542			1606	3	
566	[5] 70	566	839	(10)		1098	[3] 4		1263		1262	1544	(13)		1607	2	
567			840	(10)	840	1099			1269			1545	2		1608	2	
570			842	[9] 3		1101			1271		1270	1548	2	1548	1609	3	
577		577	848	[9] 2	848	1102			1280			1549	3		1610	1	
580			855			1104		1104	1304			1550			1612	1	
582	3		859	[11] 3	859	1105			1307		1308	1551	4		1613	1	
583			861			1106			1309			1553			1615	2	
584			870		870	1107			1323		1324	1554			1621	[18] 4	1620
585	[6] 3	585	871			1114			1325			1555	3		1622	3	
586			879			1116			1332			1556	3		1623	10	
587			887			1117	[14] 4	1117	1336		1334	1557	3		1624	3	
590			890		890	1118	2		1348			1560	[12] 4	1560	1625	10	
595		595	905	(7)	906	1119			1352		1350	1561	2		1626	6	
599			911			1120			1353			1562	2		1627	4	
600			912			1121			1354			1563	3		1628	5	
601			917			1122			1361	[12] 2	1361	1564	8		1629	18	1629
603		603	918		918	1130	3		1375			1567	2		1630	10	
616	(7)	616	919			1131	2	1131	1379		1378	1568	4		1631	1	
624		624	926			1132			1381			1569	4		1632	2	
654			927		928	1138	3	1138	1388		1388	1571	9		1633	3	
660		657	930			1139			1389			1572	[13] 10	1572	1634	1	
670			937			1150			1390			1573	8		1635	2	

[1] Phenomena characterized by decidedness, frequency, or prolonged extent toward the south occurred in or near the following years: 194, 585, 807, 993, 1097, 1117, 1203, 1308, 1361, 1529, 1572, 1580, 1716, 1789, and 1848.
[2] Often and great.
[3] Visible as far as Syria.
[4] Often.
[5] 70 days.
[6] Great, middle Europe.
[7] In low latitudes of China.
[8] 10 days.
[9] Intense.
[10] Several times, intense.
[11] Very intense.
[12] Great.
[13] Very great.
[14] Visible as far as Palestine.
[15] Great, visible as far as Portugal.
[16] Several times.
[17] The numbers in parentheses refer to observations by Tycho Brahe on the island of Hven.
[18] Very great, visible in Syria.

The aurora australis showed well-defined phenomena in Chile in 1640, in Siam in 1730, and in South America from 1737 to 1745; it was observed in the Pacific Ocean in 1773 and 1774 and at Rio de Janeiro in 1783. For the greater part these appearances correspond closely with the maxima of the aurora borealis. The greater frequency of the phenomena in southern latitudes in 1831, 1840, 1848, 1860, and 1870 is closely related to the maxima for the Northern Hemisphere.

TABLE 3.—*Years characterized by abundant and fine wine harvests* [1]

	Year of probable maximum
976, 77	976
1070	
1122, 37, 53, 85	
1201, 28, 36, 40, 56, 59, 63, 70, 76, 77, 78, 84	1277
90, 91, 93, 94	1292
1303, 13, 23, 33, 36, 37, 39, 55, 63, 72, 73, 84	1337, 1372
86, 87, 94	1386
1420, 27, 31, 32, 42, 43, 47, 57, 63	1431, 1442
72, 73, 79, 82, 83, 84, 99	1472, 1483
1504, 18, 35, 39, 40, 52, 59, 84, 93, 99	1518, 1540

[1] In this and some of the subsequent tables the author prints in bold-face type certain years, evidently with the intention of marking them as outstanding years in the occurrence of the phenomena described.—*Trans.*

TABLE 4.—*Years noted for damage by hail* [1]

	Year of probable maximum
325, 66, 77	325, 377
407	407
579, 86	579
823, 24, 32, 55, 72, 82, 89	823
906	906
1011, 57	1011, 1057
1104, 20, 62, 67, 79, 83, 84, 86	1104, 1120, 1181
90, 94	1190
1202, 22, 23, 24, 29, 37, 49, 52, 54, 55, 56	1223, 1237, 1255
57, 62, 67, 75, 79, 80, 81, 88, 89	
90, 91	1290
1312, 43, 45, 48, 55, 60	1345, 1360
1415, 37, 43, 49, 51, 60, 74, 78, 90, 91, 92	1491
1501, 2, 7, 8, 9, 13, 15, 16, 17, 22, 24	1516
25, 28, 33, 37, 38, 49, 51, 53, 55, 56	1525, 1549
57, 58, 59, 62, 63, 64, 65, 67, 68, 71	1563
72, 73, 74, 75, 76, 77, 78, 80, 82, 83	
84, 86, 88, 89, 90, 91, 93, 97	1591
1601, 6, 16, 17, 20, 21, 22, 23, 24, 26, 27	
28, 30, 33, 35, 36, 37, 40, 42, 43, 45	1637
46, 48, 49, 50, 51, 52, 53, 56, 61, 62	1649
64, 66, 68, 69, 73, 74, 75, 76, 79, 80	1676
83, 85, 86, 87, 88, 89, 93, 95, 97	1688

[1] Widespread damage in the years 1186, 1360, 1503, and 1688.

TABLE 5.—*Short and long periods of sun spots, auroras, wine harvests, and hailstorms; their mean maximum epochs, intervals between epochs, and the epochs of the 55.3-year period*

Sun spots (1)	Auroras (2)	Wine harvests (3)	Hailstorms (4)	Mean maximum epoch (1–4)	Years between epochs	Epoch of 55.3-year period
188						
	194			**190**		190
301				**301**		301
311				311	10	
321				323	12	
			325			
342				342	2x10	
354				354	12	356
360				360	6	
372			377	374	14	
	397			397	2x11	
398						
409			407	408	11	411
	434			434	2x13	
	453			453	2x10	466
501	502			501	4x12	
511	512			512	11	521
535				538	2x13	
	540					
	555			555	2x9	
	566			566	11	
577	577		579	577	11	577
	585			**585**	8	
	595			595	10	
	603			603	8	
	616			616	13	
626	624			625	9	632
	657			657	3x11	
	676			676	2x10	687
	710			710	3x11	
	727			727	2x9	
	742			742	15	742
	765			765	2x11	
778	776			776	11	
	787			787	11	
807	806			**806**	2x10	797
828	827		823	827	2x10	

Sun spots (1)	Auroras (2)	Wine harvests (3)	Hailstorms (4)	Mean maximum epoch (1–4)	Years between epochs	Epoch of 55.3-year period
840	840			840	13	
	848			848	12	
	859			859	11	853
864	870			872	13	
874	890			890	2x9	
	906		906	906	16	908
	918			918	12	
	928			928	10	
	940			940	12	
	957			957	2x9	963
	970			972	15	
974		976				
	979			979	7	
	993			**993**	14	
	1002			1003	10	
1005			1011		10	
	1014			1013		1018
			1057	1057	4x11	
	1069			1069	12	
1078						1074
	1084			1081	12	
1089						
1096	1097			**1096**	15	
1104	1104		1104	1104	8	
1112						
	1117			1117	13	
1120			1120			
1130	1131			1130	13	1129
1138	1138			1138	8	
1145				1148	10	
	1151					
1160			1162	1161	13	
	1177			1177	16	
			1181			
1185	1187			1185	8	1184
1193	1193		1190	1193	8	
1202	1203			1203	10	

Sun spots (1)	Auroras (2)	Wine harvests (3)	Hailstorms (4)	Mean maximum epoch (1–4)	Years between epochs	Epoch of 55.3-year period
	1226		1223	1225	2x11	
1238			1237	1238	13	
	1247			1247	9	
			1255			
	1262			1260	13	
	1270			1270	10	
1276		1277		1278	8	
	1280					
		1292	1290	1291	13	1295
	1308			1308	2x9	
	1324			1324	16	
	1334	1337		1334	10	
	1350		1345	1348	14	1350
	1361		1360	**1360**	12	
1372		1372		1372	12	
	1378			1380	8	
1382		1386				
	1388			1388	8	
	1401			1401	13	
	1435	1431		1435	3x11	1405
		1442				
	1462			1462	2x13	1460
		1472		1472	10	
		1483		1483	11	
1511			1516	1511	2x14	1516
	1518	1518		1518	7	
1529	1529		1525	**1529**	11	
	1538		1540	1538	9	
1549	1548		1549	1549	11	
	1560		1563	1560	11	
	1572			1572	12	1571
	1580			1580	8	
1591	1590		1591	1591	11	
1602	1604	1605		1603	12	
1617		1616	1617	1618	15	
	1620					
1626	1629	1624	1630	**1627**	9	[1] 1626

[1] 1626.0 is the second spot maximum determined by Wolf. After that date the data are rather sufficient for exact determination of the maxima and become more and more sufficient up to the present.

TABLE 5a.—*Eleven-year periods of sun spots, auroras, etc., determined more accurately* [1]

Sun spots	Auroras	Wine harvests	Hailstorms	Epoch of 55.3-year period	Sun spots	Auroras	Wine harvests	Hailstorms	Epoch of 55.3-year period
1626.0	1629	1624	1630	1626	1761.3	1760.9	1762	1762	
[2] 1639.5	1640	1637	1640		1769.7	1772.8	1775	1770	
1649.0	1647	1648	1649		1778.6	1778.0	1782	1780	
1660.0	1661	1657			1788.3	1788.2	1790	1788	1792
1675.0	1677	1678	1676		1804.2	1804.5	1804	1804	
1685.0	1683	1686		1681	1816.4	1818.5	1819	1819	
1693.0	1690		1688		1829.9	1829.9	1829	1828	
1705.5	1707	1704	1704		1837.2	1840.2	1837	1839	
1718.2	1719	1718	1720		1848.1	1850.1	1848	1848	1848
1727.3	1730.5	1727	1731		1860.1	1860.6	1860	1859	
1738.7	1739.8	1737	1740	1737	1870.1	1870.9	1870	1869	
1750.3	1748.7	1748			1883.9	1883	1883	1883	

[1] This table without number appears as part of Table 5 in the original paper.
[2] According to Kircher's testimony (Frick: *Philosophische und theologische Bedenken von den Cometen*, "*Ulm 1681, 4*") (see Wolf: *Sonnenfleckenliteratur, Nr.* 3) the number of spots visible in 1639 was equaled only three or four times in a century.

TABLE 6.—*Chief maximum epochs, number and length of eleven-yr. and 55.3-yr. periods* [1]

Periods between chief maximum epochs [2]	Interval in years	Number and length of 11-year periods	Number and length of 55.3 year periods
190 to 301	111	10x11.10	2x55.5
301 to 585	284	26x10.92	5x56.8
585 to 806	221	20x11.05	4x55.3
806 to 993	187	17x11.00	3x62.3
993 to 1096	103	9x11.44	2x50.2
1096 to 1360	264	24x11.00	5x52.8
1360 to 1529	169	15x11.33	3x56.3
1529 to 1627	98	9x10.88	2x49.0
1627 to 1848	221	20x11.05	4x55.3
301 to 1848	1,547	140x11.05	28x55.25
190 to 1848	1,658	150x11.05	30x55.26

[1] Heading of table supplied by translator.
[2] See dates printed in bold-faced type under "Mean maximum epoch" in Table 5.

Tables 5 and 5a show not only the well-known agreement between the times when auroras were well marked and visible far toward the Equator and the times when sun spots were visible to the unaided eye but also the times of several successive good vintages and years with very destructive hail nearly coincident with the maxima of solar activity and auroral phenomena. The coincident periods for all four of the phenomena could easily be increased without doing violence to the records, as a comparison of data in the first four tables will show.

The turning points of the maxima of the several periods, derived with a sure probability from the four series, are given in Table 6. The years printed in bold-faced type indicate maxima especially conspicuous because of outstanding phenomena. In all cases of the selection of the chief maximum and of the fixing of its date the chief weight had to be given to the aurora since its phenomena can be most certainly judged from what has been transmitted to the present time.

A grouping by years of the most conspicuous auroral maxima regardless of other phenomena resulted, by combining period lengths of from 54.8 to 55.8 years, in a mean of 55.6 years, or almost exactly the total length of five periods having a uniform length of $11\frac{1}{9}$ years. (*Polarlicht*, 1881. Leipzig.)

From the old observations of sun spots Wolf selected (Astronomische Mitteilungen. Nr. LXXIV) as the most conspicuous maxima those of the years 372, 840, 1078, 1133, and 1372. These are separated by 18 periods (9+4+1+4) having an average length of 55.5 years. The 90 short periods give a mean length of 11.11 years.[4]

[4] Wolf counted 42+21+5+22 short periods although the interval between 840 and 1078 on the one hand and 1133 and 1372 on the other differ by only one year (238 and 239 years, respectively). By the assumption of 43 instead of 42 periods in the first interval and the assumption of only 21 periods in the last interval the result would remain the same.

If, in view of the incompleteness of the data, one is not denied a certain license in the division of the long intervals into shorter and longer periods, then there appears in the different schemes arranged at different times—in which arbitrary treatment was avoided as much as possible—the striking agreement that the longer periods were somewhat longer than 55 years and thus include five times 11.11 years, or five of Wolf's periods. It is by no means necessary that the long intervals be multiples of the shorter periods; indeed, it appears not even advantageous on account of the greater complications arising therefrom, and it stands in opposition to the change in solar activity as a whole, which change follows a rule that is not, at any rate, simple.

As the tables, especially Table 5, show, there occur so many periods of 11 years, nearly 11 years, or intervals of years nearly divisible by 11 years between the dates at which the phenomena were observed in the earliest times that it must appear unquestionable that the 11-year period does not belong to modern times.

Previous to the year 190 the data became far more scanty. The material is limited almost entirely to a number of northern lights—of which those of 465 B. C., when the sky was lighted up for 75 days, and those of 443 B. C., when there were similar phenomena for 60 days, remind us very much of the twilight phenomena following the eruption of Krakatoa in 1883—the year of the dark sun in 45 B. C., and the Chinese observations of sun spots in the years 28 and 20 B. C. and 188 A. D. Pliny mentions 121 B. C. as the best vintage year at that period.

The sun spot observations just mentioned and a part of the phenomena to be considered as northern lights, especially those observed in southern China in 208 B. C. and at Carthage in 202 B. C., arrange themselves well in the period system previously set forth.

The fourth, sixth, eighth, twelfth, fourteenth, and sixteenth centuries were characterized by special frequency of the phenomena, auroras especially; the fifth, seventh, tenth, and fifteenth centuries, by rareness of the same. To be more exact, the dates of the chief maxima were 397, 585, 785, 1107, 1361, 1580, and 1775, with intervals, in years, as follows: 188, 200, 322, 254, 219, and 195. Since there can be inserted a somewhat less decided maximum in 990, the times with conspicuous maxima have probably recurred on an average after nearly 200 years (more exactly, 197 years).

On closer examination of the dates mentioned and in so far as the maxima of the phenomena can be determined with definiteness or sure probability, the periods of 55.25 years correspond to the maxima of the phenomena as follows: Exactly, 6 times; within 2 years, 11 times; and within 3 to 5 years, 11 times. Thus in 61 per cent of the cases the crests fall near the dates assumed as probable for the chief maxima of the phenomena.

The epochs of the chief maxima of the longer period of 59.6 years—a period derived by the writer in a theoretical manner (*Die Sonnenfleckenperioden und die Planetenstellen. Vierteljahrschrift der Naturforschenden Gesellschaft in Zurich*, 1883)—correspond with the known or probable culmination points of the causative phenomena as follows: Exactly, 9 times; with differences of 1 to 2 years, 7 times; and with differences of 3 to 5 years, 12 times—thus in 58 per cent of the cases in a manner rather close. In five cases the previously accepted epochs of the 55.6-year period coincide with the epochs of chief maxima as shown in bold-faced type in Table 5, and in five cases there are differences as follows: 13, 9, 25, 22, and 10 years. The assumed epochs of the 59.6-year period coincide with the epochs of the above chief maxima in four instances and approach them in four others, the difference in time being 21, 22, 11, and 21 years, respectively. These differences in time are noticeably near 11 years or twice 11 years. According to this the second somewhat longer period of 59.6 years is not to be disregarded.

If the above-mentioned dates of the earliest phenomena could be considered conclusive one might decide as to that one of the longer periods most favored by the data prior to the Christian era. In view of the two sun spot observations given us by the Chinese and some auroral phenomena this might prove correct, but on the basis of other data it is questionable.

The 55.6-year period makes the best showing when the above-mentioned chief maxima as taken from *Polarlicht* are made the basis of the study. In four out of the nine instances the difference does not amount to as much as 2 years and the average difference for all instances is 3.4 years. The longer period [59.6 years] gives more considerable differences and here again in a striking manner do the differences correspond closely with the 11-year periods.

The decision as to systematic change in solar activity over long periods requires continuous observation of the sun for a long time. The existing series of observations, including almost 200 years and resting on a statistical basis, would not be sufficient for investigation even if all of the data presented had equal weight. The following table illustrates this.

TABLE 7.—*Sun spots: Epochs and relative numbers* [1]

Epochs of the minima	Mean relative number for period [2]	Epochs of the maxima	Relative number at maximum [2]	Epochs of the minima	Mean relative number for period [2]	Epochs of the maxima	Relative number at maximum [2]
1700–1712	17	1706	49	1799–1810	30	1804	73
1713–1723	27	1718	50	1811–1823	19	1816	46
1724–1733	43	1727	90	1824–1833	40	1830	71
1734–1744	41	1739	85	1834–1843	65	1837	138
1745–1755	33	1750	83	1844–1856	52	1848	124
1756–1766	52	1761	86	1857–1867	50	1860	96
1767–1775	63	1770	106	1868–1878	57	1870	139
1776–1784	69	1778	151	1879–1889	32	1884	64
1785–1798	50	1788	132				

[1] Heading supplied by translator. [2] Monthly values.

The table shows agreement of the average relative number for the periods, counting from minimum to minimum, and the maximum values of the yearly mean at the time of spot maximum. The lowest values, those for 1706 and 1816, lie 110 years apart; the succeeding maxima, those for 1727 and 1837, are likewise 110 years apart, as are also the rather small values for 1750 and 1860. Should the trend in change in spots show the same behavior in the future then of necessity there would now (after 1891) follow a high maximum. However, while in 1770 the spottedness was high, in 1880, 110 years later, it fell away. Thus a conclusion can not be drawn.

If we reckon the mean epochs of the minima and the maxima from the dates given and under the assumption that the epochs need not coincide with the respective turning points for the shorter periods, then there are obtained as turning points for the minima: 1706, 1745, 1812, 1857, and 1884, with intervals, in years, of 39, 67, 45, and 27 and as turning points for the maxima: 1732,[5] 1775,[5] 1842,[5] and 1868, with intervals, in years, of 43, 67, and 26.

The minima of 1745 and 1857 are separated by 112 years, the maxima of 1732 and 1842 (as also the observed maxima of 1727 and 1837), by 110 years; on an average there lies between them 55 plus 56 years. Thus the

[5] It is striking that the auroral maxima are actually shifted to 1731, 1774, and 1840, or then there are still many phenomena in those years.

intervals are again symmetrically divided into parts of nearly equal length. The epochs of minima and maxima alternate at intervals of 26, 13, 30, 37, 30, 15, 11, and 16 years; in this only the third, fourth, and fifth, and then the sixth, seventh, and eighth intervals are symmetrical, the lengths, however, being very unequal. Up to this point 11 and 55–56 remain the best divisors, although the latter determine the main grouping only for the period 1700–1891.[6]

If the main groups 1745 to 1812 and 1812 to 1884 are taken together the average length of the interval is 69 years, while their chief maxima (obtained by averaging) are 79 years apart. The minima give 69.5 years. Counting back by one-half of this period we come to the year 1710, a time when there were low sun spot maxima and still fewer auroras than in 1745.

Let the investigation be carried out as it may, one arrives at similar varying or indefinite results since on one hand the numerical series is too short and on the other hand the course of the change in solar activity is determined not by a few simple waves, but in all probability by a series of waves having very different lengths and amplitudes. In a short series of observations even with only a moderate number of waves combining into the observed waves, the resolution becomes difficult if, as appears probable to the writer, the cause thereof is to be sought in the constantly changing positions of the planets with reference to the sun and to one another, in which the combination becomes so very complicated that only after clear knowledge of the influence of every one of the disturbing bodies will short series of observations be sufficient. If this is not the case then only very long series of observations can bring about a solution of the problem. This holds in still greater measure for the still far more complicated processes in the earth's atmosphere.

In *Mitteilungen über die Sonnenflecken, Nr.* X (p. 281), Professor Wolf comments on a period of 7.65 months or 0.638 year which may appear along with a yearly period with maxima in spring and autumn near the dates of the equinoxes.

In *Astronomische Mitteilungen, Nr.* LVI (p. 197), Wolf employed periods of 10, 11, and 81 years with the view of deriving a formula for the representation of the sunspot situation. In the next volume of that publication (LVII) the first two values were fixed more accurately at 9.917 and 11.33 years.

In *Astronomische Mitteilungen, Nr.* LXXIII, Wolf announces that he has been led to take a period of 66.67 instead of 55.56 years, and this was followed by taking (in *Nr.* LXXIV) 83.33 instead of the 81 years mentioned above.

In addition there may be mentioned the depression in 1863, occurring at the time of Jupiter's aphelion, and the following reaction (mentioned by Wolf in *Astronomische Mitteilungen, Nr.* XXV) and the fact that similar anomalies appeared at the time of earlier aphelia while at several perihelia there probably occurred the opposite case. "It is not improbable that there is in this a certain conformity to law and not accident."

[6] Through the investigation of a series of phenomena Brückner arrives at a period of 32 years. The figures presented by him (in Gäa, B. 27) result from durations of wet and dry, cold and warm years extending over periods of 32 to 34 years, and from the period of advance in glaciers, 35 years (that is, 32, 34, or 37 years), or then in general periods of 3 times 11 years or periods that are one-half of the 69-year period.

By Dr. Fruh (*Vortrag auf dem Rathhause Zurich im Fruhjahr* 1892) and also by Brückner the vintage is said to show the 32-year period. On the basis of a rather abundant collection of yields for 15 years, a compilation that is hardly excelled to-day by any other wine statistics, the writer was able to give (*Nr.* XXXVI, *Vierteljahrschrift der naturforschenden Gesellschaft*) the following 5-year totals: 1825–1829, 8.7; 1830–1834, 5.2; 1835–1839, 6.4; 1840–1844, 4.6; 1845–1849, 5.5; 1850–1854, 4.2; 1855–1859, 4.7; 1860–1864, 4.4; 1865–1869, 6.2; 1870–1874, 4.9; 1875–1879, 4.6; 1880–1884, 4.5; and 1885–1889, 3.6.

According to these values and those of the original table the chief maxima (1826 and 1870) are separated by 44 years. The interval between the chief minima can not be determined even approximately.

The preceding remarks, all based on detailed studies, support lengths of period that are often rather variable and certainly support what has been said before on the complicated course of the change of the phenomena on the sun.

When considered more closely, the period of 66.67 and 83.33 years must approximate the older observations, which conform to the period of 55.56 years since—if one does not wish to deny the 11-year period in earlier ages—the 66.7-year period, including one more 11-year period than the 55.6-year period, must frequently conform well if the 55.6-year period is generally satisfactory. It is the same with the 83.33-year period containing exactly 1.5 times 55.56 years. A period of 111 years will conform still better to epochs separated by twice 55.56 years.[7]

As to the smaller periods, that of 11.1 years is to be adhered to for the present. There is no denying that it represents the mean length of the shorter period of solar activity, terrestrial magnetism, auroras, etc., not only for the last centuries, but as far back as the observations extend or as far as they can be held sufficiently accurate. These waves of phenomena with their maxima and minima which compose the secular periods or which divide the latter into smaller divisions are in turn made up of short waves whose amplitudes increase at the time of maxima and decrease at the time of minima, but always remain perceptible.

Wolf first found (*Mitteilungen über die Sonnenflecken. Nr.* X), as already noted, a period conforming to the year on the earth in the manner that the spots were observed to be somewhat more numerous at the times of the equinoxes than in other seasons. After the use of a longer series of observations this period lost in definiteness. In its place there plainly appeared a period of 0.638 year, which is somewhat longer than the siderial period for Venus, 0.615 year. The period corresponds exactly to the mean of the synodic periods of Venus relative to Jupiter and Saturn $(0.649+0.628)\div 2$ equals 0.638. Also this interval approaches one-half the synodic period of Venus relative to the earth, $1.598\div 2$ equals 0.799, and is nearly twice as great as the synodic period of the earth relative to Mercury, 0.317×2 equals 0.634.

Wolf further found, as mentioned above, a period of 9.917 years, which in combination with that of 11.33 years could approximately produce the 11.1-year period with its deviations from the mean. This period of nearly 10 years corresponds almost exactly to one-half the synodic period of Jupiter relative to Saturn, $19.858\div 2$ equals 9.929 years.

Now if Wolf, in *Astronomische Mitteilungen, Nr.* XXV, points out the possible influence of the planets, especially Jupiter at perihelion or aphelion, then with the above values have we approached farther to the point from which the writer proceded when, in 1866, he first made public the hypothesis: "The changes in sun spots (now better denominated solar activity) may originate in the influences of the planets on the central body." While the manner of manifestation is not the same, the nature of the action is to be viewed as in agreement with the laws that relate to the attraction of the sun and moon as evidenced in the ebb and flow of the ocean. Referring to the *Programm des eidgenossischen Polytechnikums* von 1866; Wolf's *Astronomische Mitteilungen, Nr.* XXV; *Die Sonnenflecken-Periode und die Planetenstellung* in *Vierteljahrschrift der Naturforschenden Gesellschaft in Zurich, Jahrgang* XXVII; *Die wichtigsten periodischen Erschein-*

[7] The value of 69.5 or 70 years mentioned above corresponds to 1.25 times the length of the 55.6-year period.

ungen (Leipzig, 1889) by the writer; etc., it may be remarked briefly that when the true time of the sun's rotation is taken as 25.234 days (after Spörrer) and 25.74 days (after Buys-Ballot) the respective synodic times are: For Mercury, 35.37 and 36.38 days; for Venus, 28.42 and 29.06 days; for the earth, 27.10 and 27.687 days; and for Jupiter, 25.38 and 25.89 days.

Without considering the remaining planetary actions, which appear but little effective according to the hypothesis mentioned, there results for the four planets alone an important combination of smaller influences for shorter periods.

If we assume the period of 27.6868 days, first derived by Buys-Ballot from the temperature observations of European stations and reflected in solar activity, auroras, terrestrial temperature changes, and other phenomena,[8] to be produced by the synodic revolutions of Venus and Jupiter, which are most influential on the sun, then, reckoning from Venus the rotation period of the sun would be 24.65 days. This value agrees closely with periods determined as 24.12 days from meteorological phenomena, 24.33 days from magnetic phenomena, and 24.7 days from spot observations.

Since Venus and Jupiter must have nearly the same influence on variability of solar activity—if the hypothesis on planetary influence based on the laws of attraction corresponds to fact—there must be in the observations two almost equal waves, one of 25.9 and the other of 29.1 days, combining into the mean wave of 27.67 days.

Another derivation of this short period would be possible through recourse to an intramercurial planet with a period of revolution amounting to 50.577 days. (See *Vierteljahrschrift der Naturforschenden Gesellschaft in Zurich*, Nr. XXVII.) If it is desired to explain this short period as being a mean period from the synodic revolutions of Venus and Jupiter relative to the sun, then the above values for it must change to 26.07 and 29.29 days. The latter value now agrees closely with that of 29.39 days determined by J. Unterweger (*Die kleinen Perioden der Sonnenflecken.* Wien. 1891) from Tacchini's and Wolf's observations from 1880 to 1887. If investigation is made of the series of observations presented by Unterweger in statistics and graphs, corresponding increases are actually found 98 times in 112 periods of 26.07 days and 76 times in 99 periods of 29.29 days. If this result is well founded, then after every 0.3245 year, or 118.54 days (one-half of the synodic period of Venus relative to Jupiter), the waves must alternately increase and decrease. In fact, in 13 cases (especially striking on June 30 and October 15, 1883) the higher values were well marked and in other cases still noticeable in variable degree, so that in the 2,685 days taken there fall 23 periods.

If this compilation is investigated relative to the 27.687-day period then one finds—as in the earlier contributions of the writer (*Beziehungen der Sonnenflecken zu den magnetischen und meteorologischen Erscheinungen* in Wolf's *Astronomische Mitteilungen*, Nr. XXVII) also in the series of spot observations studied by Unterweger—that it represents that spots occur more abundantly in 80 out of 105 cases (76 per cent) of the 27.687-day period. Increased spottedness frequently appears at the midway point in the length of the period, 13.84 days after the maximum, and 77 cases (76 per cent of 105 cases) of secondary maximum can be pointed out. Over 60 per cent of the number of prominences do not depart more than four days from the theoretical mean. In 1880, 1882 to 1883, 1885, and 1887 the times of more abundant spots correspond in marked manner to the epochs of the 27.687-day period; in the remaining period they correspond more to the intermediate halfway points, and only from March, 1881, to March, 1882, does there take place a reversal in the two epochs. In the meteorological phenomena the 14-day epochs generally occur rather regularly, while on the sun many of these fail to appear or are not observed. The reversal after every two or three years occurs in such way that it can be thought to be caused by two waves varying slightly in intensity so that little by little the secondary waves gain upon the primary until they attain the ascendency.

A survey of the numerical values of the series of observations, and especially their graphic representation, allows hardly any other impression than that the resultant curves are made up of individual primary curves of unequal length and amplitude. The difference between the heights of the wave crests and the depths of the troughs increases at the times of the maxima and decreases at the times of the minima. The process reminds one very much of the flood curves of the ocean. If in these the influences of the sun and the moon as well as the local conditions and the effects due to the nature of the coast, depth and position of the sea can be examined with relative ease, it becomes more difficult with the spot curve. This is composed of a rather large number of waves. The most natural assumption as to the cause of the production of the individual waves leads more and more back to the planets. On account of mass and distance Jupiter, Venus, Mercury, and the earth must be viewed as most disturbing; Saturn and the other planets less effective in this way. The inner planets come into consideration chiefly in relation to the shorter waves, the outer planets in relation to the longer waves. The probable influence of comets, meteor swarms, and the like, or even the movement of the sun and its system, in space can be eliminated for the present even in considerable degree.

What has been said indicates the difficulty that presents itself when definitive investigations are undertaken while there are not available for each phenomenon to be studied far longer and, especially, more accurate series of observations than those now at hand. For periods of 50 to 75 years the observations must extend over 100 years since only in few cases do the periods always show the same length, oscillating for the most part about a mean length. For temperature and rainfall some series extend back to the year 1700, for river stages, ice conditions, thunderstorms, winds, etc., only to 1750. Air pressure observations came in later. Only rare reports on glacier changes are available for the preceding century. Crop statistics began in very recent times. Vintage statistics for a rather large region with data on the yield for definite surface extend (in Prussia) only as far back as 1820. If we add incompleteness to rareness of older series we can judge at once how great the accuracy and credibility of the same can be in by far the greatest number of cases when the epochs are separated by 50 or more years. For the present we must be satisfied with the determination of shorter periods. The determination of longer periods can be attempted only in rare cases. In view of the complex mechanism of meteorological phenomena individual series of observations are but little sufficient for discovery and confirmation of laws. If there is satisfaction therewith there should be no surprise at contradictions that arise. From individual series there can be found and maintained more or less complete contraries.

[8] Among other things this agrees well with the magnetic observations by the Austrian Polar Expedition to Jan Mayen in 1882-83 and observations up to the present in middle Europe.

WINTERS IN WESTERN EUROPE [1]

By C. EASTON

[Translated by W. W. Reed]

INTRODUCTION

In 1917, when my second study on the climate of western Europe was in press, M. J.-P. van der Stok urged the publication of the historical data that I had used in my research.

Evidently such a publication would be of some use. To assemble this information which related to the period extending from the distant past up to the present, and to a large part of Europe, was not an easy task and required much time. The comparison and critical examination of text, the necessary selection and methodical classification of the material occupied my time for several years. The histories of the abnormal winters are scattered through volumes or pamphlets which are very often not at hand for those who have need of them, and, in addition, isolated notes have a very limited value. In short, there did not exist any publication in which the character of the winters of western and central Europe was described in a few words, supported by the testimony of chroniclers and historians. This can be said without discounting at all the value of the important works of historians and meteorologists from Pilgram and Pfaff to Norlind, Speerschneider, and Vanderlinden, who for the most part have treated this matter only partially, limiting themselves to a rather short period or to a limited part of the climatic province.

The revision and discussion of the historical data necessitated a complete rehandling of the text although I have strictly limited myself to the climatic zone of western Europe when it was a matter of drawing conclusions and have occupied myself only with the winters, leaving out the other seasons, reports of floods, famines, etc., which are abundant in the old chronicles. It appeared to me rather evident that it was necessary to have recourse to an inversion of chronological order in order to profit as much as possible from historical information often vague and little worthy of belief. The modern thermometric observations alone constitute a safe basis for the methodical study of the meteorological indications drawn from the chronicles.

I resolved, then, to begin by assembling and discussing modern observations. It goes without saying that this entailed an enormous increase in work, so, in order not to delay indefinitely the publication that I had in view, I had to limit myself to meteorological observations made at representative stations in western Europe and the immediate vicinity. The great advantage of this method lies in the fact that it permits us to supplement considerably the historical data with the aid of results infinitely more precise and less arbitrary derived from the modern meteorological observations.

This comparison between modern observations and historical data is admissible only when one proceeds under the following assumptions: (1) In this part of the world the climate has not changed appreciably since the beginning of the Middle Ages, and (2) the variations in temperature have not been caused by periodicities with considerable amplitude. Arago in his study "on the thermometric state of the terrestrial globe" (Oeuvres T. VIII, p. 395) says: "Everything conspires to prove that the climates of Europe are in general in a state of equilibrium," and in the course of his study we have never encountered an argument tending to render the contrary opinion probable. Further, Angot (Ann. Bur. Centr. Met. Fr. 1897, B. 167) thus concludes his remarks on the variability of temperature:

> It is seen that at all of the stations the number of departures of a given order satisfies very exactly the theory of errors, which permits us to consider these departures as due to fortuitous causes. * * * These conclusions, it is to be understood, must be limited to the region studied in this work. [This region occupied the larger part of our "climatic province."]

In addition, J. von Hann sees no indication of a progressive change in temperature in Europe: "In none of the critically treated, long-period series of temperature records can there be demonstrated a continuous (noncyclic) change in annual temperature" (Hdb. d. Klimatologie, Bd. I, 3e Aufl. p. 348. *See also* Ekholm on the observations of Tycho Brahe, 1582–1597) compared with present climate (Hann, ibid., p. 347). The historical data that follow do not support at all the theory of some modern meteorologists that the climate of western Europe has probably become more severe and cold since about the year 1000.

As to the periodicities often conjectured, it is almost certain that they can not have the effect of overturning the distribution supposed here. However, to guard as much as possible against such an influence, we have taken the precaution to consider only multiples of the period of 89 years (1205–1916 equals 8×89) as the longest that can be taken into consideration. (*See* Easton, loc. cit. W. Köppen, Ann. d. Hydrogr. u. Marit. Meteor. XXV, 11, 1917, and Met. Zeits, XXXV, 3, 4; J.-P. van der Stok, Het Klimaat van Nederland. Tidjs. K. N. Aardrijksk. Genootschap XXXV, p. 348.)

The method indicated above agrees with the division of our publication into three parts.

The first part includes the modern thermometric observations, relatively homogeneous among themselves, and having a sufficient degree of accuracy; that is to say, after the middle of the 19th century. For the reason given above, I have made this series end with the winter of 1915–16.

The second part contains the old thermometric observations, made between the middle of the eighteenth and the middle of the nineteenth centuries; they are much inferior to modern observations, but still they can serve.

The third part contains the historical data from the most remote times to the present. However, the data previous to the year 760 and those after 1851 are to be regarded only as supplementary; they have a secondary interest only. On the other hand, the period comprised between the beginning of the thirteenth century and the middle of the eighteenth century has been treated carefully in order to be able to compare it with the scientific observations.

It is evident that the three epochs indicated here are not *rigorously* comparable.

Thus, in the third part of this work we have reproduced as information, even if somewhat fragmentary, all of the historical data available, selected and methodically

[1] Reprinted in part from Les Hivers dans L'Europe Occidentale, by Easton, C., Docteurs-Sciences, Membre du conseil de L'Institut Royal Météorologique des Pays-Bas President de L'Association Météorologique et Astronomique. Librairie et Imprimerie ci-devant E. J. Brill, Leyde, 1928.—Ed.

arranged, but our chief conclusions relate only to the three periods as follows:

(a) 1205–1756, historical data;

(b) 1757–1851, old thermometric observations; and

(c) 1852–1916, modern thermometric observations.

For each winter of these seven centuries we have been able to compute a coefficient (often approximate) indicating the temperature of the (meteorological) winter (western Europe), whence there are easily derived general terms such as "severe winter," "warm winter," etc., which will have (henceforth) a value less subjective, their classification being based on the results obtained for winters since 1852, by the aid or relatively exact scientific observations. These winters could be arranged in the order of increase or decrease in temperature so that the severity or the mildness of each winter could be immediately judged from its place in the list. The simple inspection of another table suffices to make known whether a winter, after 1204, was about normal or more mild or more cold than ordinarily. It is needless to emphasize the provisional character of these indications at least for the winters whose temperature was rather near the normal, but there is reason to believe that they do not depart too much from the truth.

The arrangement of the "Register of remarkable winters" is explained later.

Thus the critical examination of the historical data and their comparison with scientific observations puts us in a position to give to the winters of past centuries a "coefficient of temperature," although the historical data do not relate to temperature alone, but to the humidity, snow, etc., of a winter, but it follows that the significance of the terms "mild winter," "severe winter," etc., as we employ them will never coincide exactly with the popular terms which are (besides) always vague, arbitrary, and impossible to define.

While the "coefficients" relate only to the (province) of western Europe the passages by old writers on *all* Europe (with the exception of eastern and southern regions) assembled here. The bibliography, which contains more than 500 publications, mentions the place where the report was written or the region to which the information relates, which is indispensable in judging their extent and value.

The results obtained have nothing of definiteness. In the course of this long drawn out work we have had many times occasion (opportunity) to determine the lack of precision in certain historical data and even in certain scientific observations. On the other hand we are convinced that the historical data extending over more than 10 centuries, are often—for the *abnormal* winters—remarkably exact; they constitute a unique and valuable source of climatology.

* * * * * *

CHOICE OF METEOROLOGICAL ELEMENTS

1. The monthly means. These constitute in our opinion the best basis for determining the character of the winter on the condition of having been determined with much care. However, in themselves they are insufficient for in an abnormal winter, for example, with December well below and February well above the normal, it often happens that these anomalies disappear in the final figures.

2. Days with frost. These constitute an element noted for centuries, but which is very variable according to local conditions.

3. Days without thaw (ice days) are important for the very cold winters, but useless for the classification of moderate or mild winters.

4. Days with maximum $-10°$ C. or below. These very cold days complete the indications given under (3). (The same remark applies.)

5. The absolute minimum of a winter is often found in the old publications, but it gives no idea of the character (more or less cold) of the season and it does not satisfy the needs of modern methods.

6. $1/2\ (a+b)$, a denoting the sum of the minima, b that of the maxima of temperature in a series of at least 14 days when the temperature fell below zero.

7. The sum of the negative means for the days from November to April. (Hellmann.)

All of these elements, alone or combined, can have a certain usefulness; for the particular purpose that we have before us we have believed it (advantageous) to make use of Nos. 1, 2, 3, and 4, supplementing these data with:

8. The mean of the three extreme minima in the different months of the same winter, November to March.

Thus in the present work use has been of the—

Monthly mean.
Number of frost days.
Number of ice days.
Number of very cold days.
Mean of three minima.

Discussion of the observations, winters of 1852–1916.—For all of the winters and for the nine selected stations, Bremen, Uccle, De Bilt, Paris (St. M.), Greenwich, Angers, Toulouse, Lyon, and Strasburg, there has been calculated the departure from the normal (d), the probable error (e) and the value d/e, that is the departure expressed in multiple of the probable error.

The other meteorological elements (outside of mean temperature) have been combined to derive a "coefficient of intensity." With the exception of the series of three minima it has not been possible to apply the rigorous method followed for the monthly means, this stands out from the simple inspection, for example, of the series of ice days for Toulouse or Angers.

* * * * *

After having calculated in this manner a coefficient for each meteorological element it was necessary to combine these coefficients in a proper manner to set forth the greater or less intensity of the cold of any given winter. In general we have given the weight of 2 to the series of three minima because it appears to us to offer the best measure of the greater or lesser intensity of cold from November to March and because this element can be obtained almost without break for all of the stations; the other coefficients, frost days, ice days, very cold days ($-10°$ C.) have the weight 1, in the case where one or several of the elements were lacking, we were content to use the others. The combination of the elements here named for the coefficient of intensity, that combined with equal weight with the mean coefficient (monthly mean) gives the coefficient of temperature, which we regard as the best characterization of the winter temperature.

Results.—It would take too much space if we gave *in extenso* all the series that have served to establish the results, according to the method explained above, for the nine stations 1852–1916 and the five stations 1757–1851. An appendix contains the principal series.

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Outside of the historical register of remarkable winters the principal results of the present work are summarized in six tables (following the register):

Table 1 (*1852–1916*).—Coefficients of temperature: This table gives for the stations Bremen, Uccle, etc.: (*a*) The mean coefficient (monthly mean) for each winter, (*b*) the coefficient of intensity, (*c*) the temperature coefficient. For each winter the temperature coefficients of all of the stations have served for the derivation of a temperature coefficient (general) for the climatic province. (Weights: Paris, 4; Angers, Lyons, De Bilt, 3; Uccle, Bremen, 2; Strasburg, Toulouse, Greenwich, 1.)

Table 2 (*1852–1916*).—Classification of winters: This table shows the 65 winters in the order of decreasing temperature according to the temperature coefficient for the climatic province. (Table 1, last column.) It gives general indications, "mild winter," "severe winter," etc., according to the principles of our classification.

Table 3 (*1757–1851*).—Temperature coefficients: This table furnishes the same elements as Table 1, taken from the observations of Zwanenburg, Paris, Greenwich, Toulouse, and Basel. For the general temperature coefficients there were given weights as follows: 3, 3, 1, 1, 2.

Table 4 (*1757–1916*).—The winters of 1757–1916 classified according to (increasing) temperature: Order numbers, coefficient of temperature, general characteristic.

In the period we count 1 "great winter," 5 very severe, 12 severe, 23 cold, 17 rather cold normal (winters) 42 normal, 21 rather moderate normal winters, 30 moderate, 6 mild, 3 very mild.

Table 5 (*1265–1756*).—The winters 1205–1756 classified according to their (increasing) temperature: Classification of these winters according to historical information. There have been entered in this list only the winters considered abnormal. There has been assigned to these winters only the following (approximate) temperature coefficients (see p. 10) 4, 10, 17, 21, 25, 28, 31, 34, 36, 38, 42, *54*, 60, 63, 66, 70, 74, 79, 82, 90. The coefficient *54* has been given to 257 winters where there is found no mention of a certain (character) and all of which have been considered normal, there is very great probability that these winters did not depart much from the normal; a certain numbei of these winters were probably "rather moderate."

In this period of 552 years we count 4 "great winters," 13 very severe, 46 severe, 74 cold, 43 rather cold normal winters, 257 normal or rather moderate, 87 moderate, 24 mild, and 4 very mild.

Table 6.—Chronological list of winters from 1205 to 1916, and some remarkable winters prior to 1205, with their temperature coefficients (approximate up to 1756) and a general characterization. (Data prior to 764 very uncertain.) In the characterization of the winters 1757–1851 preference is given to historical evidence (coefficients in parentheses), in case the difference between the scientific result and the popular impression is important; after 1851 we have confined ourselves to the scientific observations.

This list, based on historical data, brought into agreement with modern scientific observations, show at a glance the character of all remarkable winters mentioned in the history of western Europe, and for a period of seven centuries the approximate character of all other winters, even those which departed but little from the normal.

Doctor Eaton, as indicated in his foreword, now presents a summary of the great mass of historical data used in his previous researches which were published under the following named titles: Oscillations of Solar Activity and the Climate Proc. R. Ac. Sci., Amsterdam, November 1904 and May 1905; and "Periodicity of Winter Temperatures in Western Europe," published by the same institution in August, 1918.

The essentials, so far as given in the records, covering the winters between 396 B. C. and 1928 A. D. are summarized under the caption "Register of Remarkable Winters," the text of which takes up 131 of the total of 210 pages in the work. The tables which give in brief form the results of his studies are as follows:

Table I.—Coefficients of temperature winters of 1852–1916.
Table II.—Classification of winters of 1852–1916.
Table III.—Coefficients of temperature winters of 1757–1851.
Table IV.—The winters of 1757–1916 (classed according to their temperature, increasing order).
Table V.—Classification of winters 1205–1756 (classed according to increasing order of temperature as given in historical records).
Table VI.—Chronological list of winters from 1205 to 1916 and remarkable winters before 1205 with their coefficients of temperature, approximate to 1756–(Characteristics very uncertain before 764).

In an appendix the values of $\frac{d}{e}$ which served to determine the "coefficient moyen" for each of the nine stations for the period 1852–1916 are given.

The outstanding winters in western Europe during the ninteenth century according to Doctor Eaton's classification were:

1830 great winter in the sense of extreme cold.
1880 very cold.
1891 very cold.
1834 very warm.

The correspondence between the winters of western Europe and those of eastern United States is not close; thus 1830, the winter of greatest cold in more than a century in western Europe, was not unusually cold in eastern United States, nor was the winter of 1834 unusually warm. Nevertheless, Doctor Eaton's work will serve as a foundation on which the synchronism or lack of it in temperature fluctuations the world over may quickly and easily be made.—*A. J. H.*

WEST INDIAN HURRICANES OF AUGUST, 1928

By R. HANSON WEIGHTMAN

August 3-12, 1928.—From reports received by mail it is evident that a tropical disturbance, the first of the season, passed on a westward course some 75 to 100 miles north of the Leeward Islands during the 3d and 4th of August. (See fig. 1, track 1.) The first telegraphic report of its existence was received from the S. S. *Sixaola*, just west of Acklin Island on the afternoon of the 5th. The center moved northwestward with slowly increasing intensity and was central on the morning of the 6th about 60 miles southeast of Andros Island, Bahamas. At that time storm warnings were ordered for the southeast Florida coast between Key West and West Palm Beach. On the evening of that date storm warnings were lowered at Key West and extended northward to Titusville and caution advised for vessels off the east Florida coast north of Miami.

In the next 24 hours the center had advanced to a position about 70 miles east of Miami. Storm warnings were continued from Miami to Titusville and information was disseminated that a disturbance of considerable intensity was moving north-northwest with some indication of a recurve to the northward, caution being repeated to vessels between north-northwest and north-northeast of center. During the afternoon of that day the center had a more northern tendency as evidenced by special reports from vessels near the coast between Miami and Fort Pierce, and at 3:25 p. m. of that date a bulletin was issued stating that the storm was of hurricane intensity and apparently moving northward, and caution was advised for vessels off the South Atlantic coast south of Hatteras.

On the evening of the 7th no land observations were available between Titusville and Miami, but vessel reports south of the center indicated that it was beginning to turn north-northwest or possibly northwest. Accordingly, storm warnings were changed to hurricane warnings between Jupiter and Daytona, with advices that destructive north winds would occur early that night in the vicinity of Jupiter and that they would advance northward along the coast reaching the vicinity of Daytona by Wednesday morning, and that every precaution should be taken. At that time the center was about 20 miles southeast of Jupiter. By the morning of the 8th the center was about 60 miles northwest of Jupiter, moving northwest and emergency warnings for dangerous gales and heavy rains were issued for the interior of Florida Peninsula, north of latitude 28°. Northwest storm warnings were also ordered at Tampa and northeast storm warnings north of Tampa to Apalachicola, accompanied by the information that the disturbance, still of great intensity, was moving northwest and would cause strong northwest winds that afternoon in the Tampa region and northeast gales north of Tampa to Apalachicola during the afternoon and night; also, that high tides were indicated for Tampa Bay late that night or Thursday forenoon.

The storm continued to move northwestward with decreasing intensity to between Tampa and Apalachicola by the evening of the 9th. It then turned northward to southern Georgia bearing more and more to the northeastward until it finally passed off the coast north of the Virginia Capes during the night of the 11th.

The lowest barometer reported was 28.70 inches by the S. S. *Lempira* about 30 miles southeast of Jupiter, Fla., at 7 p. m. of the 7th. The center passed nearly over Fort Pierce as a lull was experienced between 3 and 4 a. m. of the 8th.

Observations from Fort Pierce, Fla., August 7 and 8, 1928, follow:

Time	Barometer	Wind
August 7:		
6:30 p. m.	29.78	NE.
7:30	29.76	NE.
9:00	29.70	NE.
10:00	29.66	NE.
11:20	29.52	NE.
11:45	29.48	NE.
August 8:		
12:30 a. m.	29.41	NE.
1:00	29.34	NE.
1:15	29.30	NE.
1:30	29.22	NE.
1:45	29.16	NE.
2:00	29.10	NE.
2:15	29.06	NE.
2:30	29.02	NE.
2:50	28.94	NE.
3:00		N. by E., commenced to lull and work around toward E.
3:15	28.90	
3:30	28.88	
3:45	28.85	Wind lulled; shifted by way of E. and SE.
4:00	28.84	
4:15	28.84	
4:30	28.90	SW. (estimated 90 m. p. h.).
4:45	29.00	
5:00	29.10	
5:15	29.16	
5:45	29.26	
6:00	29.30	

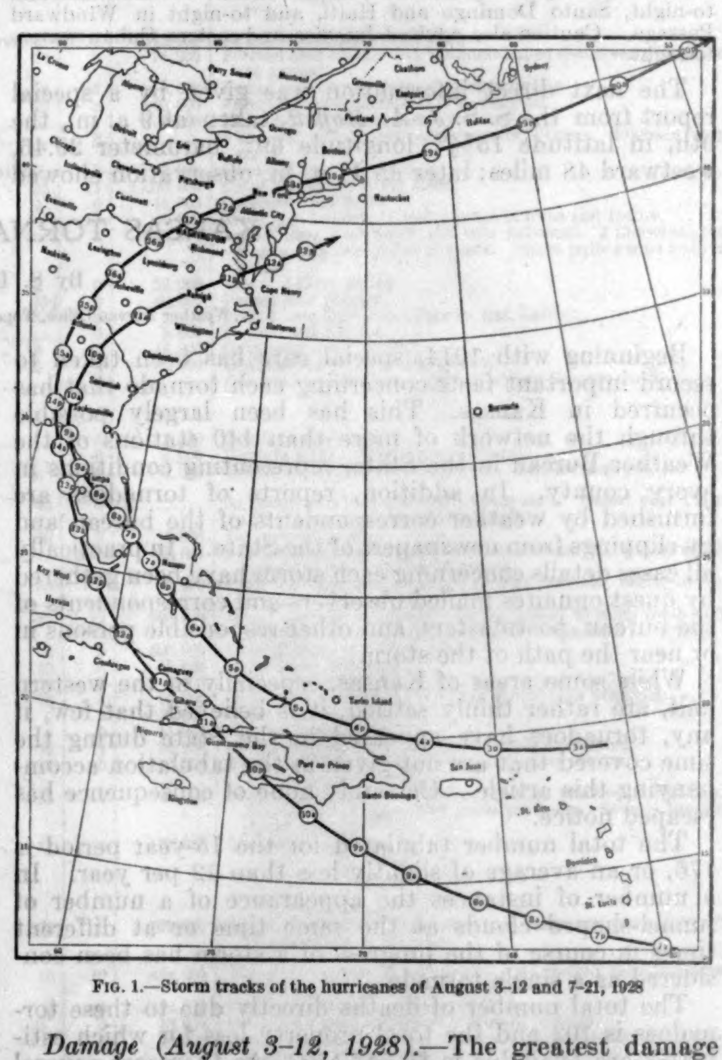

FIG. 1.—Storm tracks of the hurricanes of August 3-12 and 7-21, 1928

Damage (August 3-12, 1928).—The greatest damage occurred along and to the north and northeast of the portion of the track between Jupiter and the Georgia-Florida State line.

Citrus fruits.—Most of the damage was to citrus fruits, estimated by the State Citrus Exchange at 1,000,000 boxes.

Telephone and telegraph.—Considerable damage was done to telephone and telegraph equipment, to the extent of many thousand dollars, specific figures not being available.

Highways.—Highways suffered from the south-central east coast where the storm approached the coast, thence northwestward to point of exit. Minimum of $100,000 estimated by Florida State Highway Commission.

Bridges.—Washing rains damaged roadways and bridges, demoralizing schedules for several days.

Trees.—Many trees were uprooted in Osceola, Brevard, Orange and Marion counties.

Buildings and houses.—The following counties reported damage in connection with houses and buildings: Marion, Brevard, Osceola, and St. Lucie. Reports are still incomplete as to damage.

Storm of August 7–21, 1928.—The disturbance was first noted as one of slight to moderate intensity west of Bridgetown, Barbados, on the evening of the 7th, advancing west-northwest. (See fig. 1, track 2.)

On the evening of the 8th, the following was issued:

Tropical disturbance central about 150 miles south-southwest of Porto Rico moving northwest or west-northwest, of moderate intensity. Caution advised Santo Domingo, Haiti, Jamaica, and contiguous waters next 24 hours. Disturbance is apparently heading for southern Haiti coast.

The following was issued on the morning of the 9th:

Tropical disturbance probably of moderate intensity, 75 to 100 miles south of Santo Domingo coast, moving northwest. Caution advised against; strong northeast and east winds this afternoon and to-night, Santo Domingo and Haiti, and to-night in Windward Passage. Caution also advised Jamaica and eastern Cuban waters to-night.

The next direct information was given by a special report from the S. S. *J. A. Moffett*, taken at 9 a. m., the 9th, in latitude 15½°, longitude 69°, barometer 29.46, westward 48 miles; later an 11 a. m. observation showed wind shifting to south. Accordingly, special advices were sent to Haiti and Jamaica as follows:

Disturbance of considerable intensity moving apparently west-northwest. Extreme caution advised Jamaica and southern Haiti.

Belated reports indicate that a very small but destructive disturbance passed over extreme southwest Haiti during the 10th.

On the morning of the 11th the center of the disturbance was over extreme eastern Cuba, the U. S. S. *Arkansas* in Guantanamo Bay having reported an east wind of 78 m. p. h. at 4:30 a. m. of that date.

As far as telegraphic reports are concerned, the center was not definitely traceable for the next 24 to 36 hours, but reports received by mail indicate that a small center passed over the province of Oriente, Cuba, where some banana trees were blown down, and was central on the morning of the 12th on the north coast of central Cuba. Observations during the afternoon of the 12th indicated a disturbance southeast of Key West, and an advisory was sent to southern Florida stations. At 8 p. m. of that date it was evident that a small but intense disturbance was advancing northwestward toward the Florida Keys and advices were disseminated for gales over this region, possibly reaching hurricane force near the center. Storm warnings were ordered from West Palm Beach on the east coast southward to Key West and thence northward along the west coast to Punta Russa and Punta Gorda. On the 13th storm warnings were extended north and west to Mobile. The disturbance advanced on a north-northwest course just off the west coast of Florida and passed inland a short distance west of Cedar Keys, attended by gales in that region. Gales were also experienced along the coast and over the Florida Keys.

KANSAS TORNADOES, 1914–1928

By S. D. FLORA

[Weather Bureau Office, Topeka, Kans., November 13, 1928]

Beginning with 1914, special care has been taken to record important facts concerning each tornado that has occurred in Kansas. This has been largely possible through the network of more than 140 stations of the Weather Bureau in the State, representing conditions in every county. In addition, reports of tornadoes are furnished by weather correspondents of the bureau and by clippings from newspapers of the State. In practically all cases details concerning each storm have been gathered by questionnaires mailed observers and correspondents of the bureau, postmasters, and other responsible persons in or near the path of the storm.

While some areas of Kansas, especially in the western half, are rather thinly settled, it is believed that few, if any, tornadoes have appeared in the State during the time covered that are not given in the tabulation accompanying this article. Certainly none of consequence has escaped notice.

The total number tabulated for the 15-year period is 176, or an average of slightly less than 12 per year. In a number of instances the appearance of a number of funnel-shaped clouds at the same time or at different times in course of the progress of a storm has been considered as a single tornado.

The total number of deaths directly due to these tornadoes is 102 and the total property loss for which estimates are available is $9,547,150. As there are several rather damaging tornadoes for which no estimates are available, the actual property loss is probably a little in excess of $10,000,000, or approximately $700,000 annually. This does not include losses due to violent winds not of tornadic origin, which have been considerable.

Undoubtedly, Kansas is in what is known as the tornado belt of the country but it is interesting to note that it lies at the western edge of this belt. Of the 176 storms tabulated 45 per cent occurred in the eastern third of the State, 34 per cent in the middle third, and but 21 per cent in the western third.

There is no reason to think that Kansas is more infested with tornadoes than several other States. While statistics for the past 15 years are not available for comparison, the discussion of tornadoes in the 8-year period, 1916–1923 by Hunter, MONTHLY WEATHER REVIEW, May, 1925, showed during 25 years more tornadoes per unit area in Iowa than in Kansas and practically as many in Arkansas, Illinois, and Missouri.

Losses of lives and property during an 8-year period were much greater than in Kansas in Alabama, Illinois, Indiana, and Minnesota. This, of course, may be partly due to the greater density of population and buildings in states east of Kansas although the greater average length of paths of the eastern tornadoes probably has much to do with it.

Comparatively few Kansas tornadoes travel more than 40 miles. Of the 176 tabulated but 5 left paths of 50 miles or more in length. The longest was the violent storm that struck Hutchinson on May 7, 1927, which disappeared 118 miles from its point of origin, though

its actual path, owing to meanderings it pursued, was somewhat longer. A large number of the tornadoes listed struck at but one place, then lifted and disappeared.

But three tornadoes in the history of the States have caused a property loss as great as $1,000,000. These are the Hutchinson storm of May 7, 1927, the Great Bend storm of November 10, 1915, and one that struck Augusta and near-by oil fields on July 13, 1924.

May and June are undoubtedly the outstanding tornado months in Kansas. During the 15-year period 65 of the 176 tornadoes occurred in June and 30 in May. None were reported in January or December.

The late afternoon, from 3 p. m. to 6 p. m. has been the usual time of occurrence though some tornadoes have been sighted shortly after the noon hour and some have formed almost as late as midnight. Three occurred between 3 a. m. and 5 a. m., but none during the forenoon.

Kansas tornadoes by years

Year	Number occurring	Loss of life	Property loss	Year	Number occurring	Loss of life	Property loss
1914	8	10	$185,000	1923	18	1	$267,000
1915	10	20	1,280,000	1924	15	2	2,134,300
1916	8	3	249,000	1925	12	0	377,000
1917	18	31	1,881,000	1926	16	0	161,200
1918	6	10	810,000	1927	19	19	1,471,750
1919	5	5	229,000	1928	25	1	286,900
1920	4	0	202,000				
1921	6	0	5,000	Totals	176	102	9,547,150
1922	6	0	8,000				

County and year	Date	Hour	Storm moved from—	Width of path	Length of path (miles)	Loss of life	Property damage (estimated)	Remarks
1914								
Rice	Mar. 28	5:30 p. m.	SW			0	$85,000	Chief damage in Frederick. At least 2 funnel-shaped clouds were seen.
Sumner	Apr. 17	do	SW	¼ mile	10	0	100,000	Lasted 30 minutes; 12 persons injured.
Butler	June 1					0	Small.	Occurred about 7 miles north of Eldorado.
Smith	June 2	6:15 p. m.				0	None.	Tornado cloud failed to reach the ground.
Bourbon	Aug. 19	3:00 p. m.				0	Small.	Tornado cloud did not quite reach the ground.
Elk, Wilson and Greenwood.	Oct. 9	5:30-6:30 p. m.	NW					3 tornadoes reported, though probably were different appearances of same cloud; 30 houses and barns destroyed. Damage not estimated.
Montgomery	do	7:30 p. m.				10		Loss of life is total for the five storms of October 9.
Cherokee	do	8:00 p. m.				0		Occurred near Galena. Very little damage.
1915								
Wichita	June 3	6:00 p. m.	SW	1 mile	Several.	1	$40,000	Struck 3 miles northwest of Leoti.
Kiowa, Pratt, Stafford, and Pawnee.	June 11	6:30 p. m.	SW	½ mile	50	0	75,000	Formed near Mullinville; 8 funnel-shaped clouds seen; 3 reached the ground.
Pottawatomie	June 17	4:00 p. m.	SE	50 yards	4	5	5,000	Passed near Onago, path decidedly curving.
Coffey	do	5:00 p. m.	SW	¼ mile	10	0	40,000	Formed 4 miles northwest of Burlington.
Bourbon	do	9:00 p. m.	SW			0	53,000	Chief damage in and near Fort Scott.
Grant	June 23	3:00 p. m.				0		4 tornado clouds seen northwest of Ulysses. Damage very small.
Crawford	June 30		NW	200 feet	Several.	0	2,000	Occurred near McCune.
Barton	Nov. 10	7:00 p. m.	SW	1,000 feet	35	11	1,000,000	Chief damage in Great Bend.
Pratt	do	8:30 p. m.	SW	100 feet	4	0	15,000	Occurred near Pratt.
Sumner	do	10:00 p. m.	SW	600 feet	16	3	50,000	28 persons injured. Chief damage at Zyba and Derby.
Bourbon	Apr. 19	4:30-5:00 p. m.	SW		30	3	150,000	Passed near Fort Scott and into Missouri. 2 funnel-shaped clouds seen near point of origin. Storm path a mile wide in places.
Jackson and Jefferson	do	3:30 p. m.	SW	100 to 400 feet	12	0	20,000	Town of Hoyt struck.
Allen	do	4:00 p. m.	SW	350 feet	5½	0	60,000	Passed near Elmore.
Woodson and Coffey	do	3:00 p. m.	S	250 feet	10	0	2,000	Passed near Lomando, Vernon, and LeRoy.
Wilson	do	4:00 p. m.	SW			0	3,000	Passed near Buxton.
Rooks and Osborne	May 20	7:00 p. m.		¼ mile	15	0	12,000	Originated near Codell.
Harper and Kingman	do	9:00 p. m.	SW	100 to 800 feet	25	0	2,000	Disappeared just east of Norwich.
Cherokee	Sept. 3					0		Occurred near Galena. Path short and damage small.
1917								
Allen	Mar. 22	8:00 p. m.				0	2,500	Occurred near Carlyle.
Elk	do	About 5:30 p. m.	SW			0	3,000	Damage small. Passed near Howard.
Haskell and Gray	Apr. 18	About 2:30 p. m.	SW	100 yards to ½ mile.	40	0	10,000	Originated southwest of Santanta. No towns struck.
Rooks	May 20	6:00 p. m.	SW	600 feet to 2 miles	40	0		As many as 3 funnel-shaped clouds seen. Passed near Plainville; damage comparatively small.
Decatur	May 25	1:00 p. m.	SW	300 to 500 feet	10	0	1,000	No towns struck.
Lincoln	do	3:00 p. m.	SW				2,500	2 funnel-shaped clouds followed separate paths, 1 passed southeast and 1 north of Sylvan Grove.
Elk, Woodson, Greenwood, and Allen.	do	6:30 p. m.	SW	¼ mile	58	1	50,000	Path was from near Howard to near Leanna. Storm moved 50 miles in 25 minutes.
Sedgwick, Harvey, Butler, and Marion.	do	2:00-2:50 p. m.	SW	Few rods to 1¼ miles.	65	12	600,000	Worst damage at Andale. Storm moved 40 miles in 45 to 50 minutes. At least 2 funnel-shaped clouds seen.
Montgomery	June 1	5:05 p. m.	SW	600 to 800 feet	9	3	500,000	Chief damage in Coffeyville.
Franklin	do	6:00 p. m.	SW	¼ mile.	10	0	15,000	Passed over Pomona.
Labette and Cherokee	do	do	SW	100 to 200 feet	10	0	7,000	Path extended from near Montana to near McCune.
ohnson	do	7:30 p. m.	SW	80 rods	25	4	10,000	Originated near Morse and then moved into Missouri.
Douglas	June 5	5:00 p. m.	SW	¼ mile	1	1	50,000	Chief damage at Clinton.
Doniphan	do	5:45 p. m.	WNW		4	0	15,000	Occurred near Troy.
Neosho	do	6:00 p. m.	SW	300 yards	15	1	30,000	Path extended from near Shaw to near Savonburg.
Franklin, Miami, and Johnson.	do	6:15 p. m.	SW	1 mile	40	0	10,000	Path extended from near Pomona to near Olathe.
Wabunsee, Shawnee, Jackson, and Jefferson.	do	4:22-5:15 p. m.	SW	500 to 1,000 feet	45	9	500,000	Path close to Topeka. Town of Elmont practically destroyed. Moved at the rate of 30 miles per hour. Several pendant clouds seen.
Pottawatomie and Wabaunsee.	June 12	8:30-9:00 p. m.	NW	¼ to ½ mile	15	0	75,000	Louisville struck.
1918								
Elk, Greenwood, Woodson, Allen, Bourbon, and Linn.	Feb. 27	8:00-10:00 p. m.	SW		100	0	200,000	Series of thunderstorms with 1 or more tornadoes in path. Storms ended in Missouri.
Elis, Rooks, and Osbourne.	May 20	Between 8:30 p. m. and midnight.	SW		40	10	450,000	Tornado occurred in connection with violent thunderstorms. Chief damage at Ellis and Codell.
Trego	do	6:00 p. m.		½ mile	3	0	100,000	Occurred 10 miles southeast of Wakeeney.
Logan	do	5:50 p. m.	SE	100 feet to ½ mile	25	0	10,000	Occurred 4 miles southeast of Russell Springs.
Nemaha	May 26	5:45 p. m.	SW	500 feet	22	0	50,000	Every building in Bern damaged. Storm extended to near Falls City, Nebr.
Sheridan	May 29							Damage small, occurred east of Hoxie.

County and year	Date	Hour	Storm moved from—	Width of path	Length of path (miles)	Loss of life	Property damage (estimated)	Remarks
1919								
Jackson and Atchison	Mar. 15	Noon	SW	Narrow	20	0	$13,000	Chief damage in Muscotah.
Barton	Apr. 28	5:15 p. m.	SW	150 feet	1	1	6,000	Ellinwood struck.
Trego	May 18	5:00 p. m.	SW	100 feet	10	0	10,000	Passed 3 miles to southwest of Collyer. Pursued a zigzag path.
Barton	Oct. 8	4:04 p. m.	SW	400 feet	9	4	200,000	Hoisington struck; 25 persons injured.
Do	do	4:30 p. m.	SW		8	0		Damage small; moved from near Dundee to within 2 miles of Great Bend.
1920								
Greenwood	May 3	5:20 p. m.	NW	100 yards		0	200,000	Chief damage in eastern section of Eureka.
Douglas	July 1	7:40-8:00 p. m.					1,000	Damage occurred in North Lawrence. Several incipient tornado clouds seen.
Riley	July 31	3:00-4:00 a. m.	SW	200 feet	1¼	0	1,000	Occurred 5 miles north of Manhattan.
Jefferson	Sept. 23	7:30 p. m.		¼ mile		0		Occurred near Winchester. Damage small.
1921								
Seward	Apr. 4	About 7:00 p. m.	SE			0		Damage slight; three tornado clouds seen.
Lincoln	May 9	4:10 p. m.	SW		10	0		Originated near Lincoln. Damage small.
Jackson	do	5:00 p. m.	NNW	100 feet to ¼ mile	10	0	5,000	Formed near Mayetta; 5 persons injured.
Shawnee	May 26	6:00 p. m.	WSW	100 feet	2	0		Damage very small. Occurred in western suburbs of Topeka.
Greeley	Aug. 3	4:30 p. m.	NW	do	10	0		Damage small. Occurred in thinly settled country in northwest part of county.
Meade	Sept. 7					0		No damage done. Occurred near Plaine.
1922								
Wichita	Apr. 23		NE		5	0		Damage small. Occurred northwest of Leoti.
Ellis	May 10	9:00 p. m.				0		Damage small. Occurred in southwest part of county.
Wichita	Aug. 8				1½	0	3,000	Occurred in northeast part of county.
Edwards	Sept. 8	2:36 p. m.	SW	½ mile	2	0	5,000	Town of Fellsburg struck.
Clark	Nov. 4	1:00 p. m.	SW		9	0		Considerable damage. Formed southeast of Mineola.
Mitchell	do					0		Damage small. Occurred at Beloit. Path short.
1923								
Brown and Doniphan	Mar. 3	5:00-5:35 p. m.	WSW		35	0	14,000	Originated near Baker, struck Elwood, and moved into Missouri through St. Joseph, where damage totaled $50,000. Path not continuous.
Reno	Apr. 2	5:30 p. m.	W	300 feet	1	0	50,000	Town of Partridge struck.
Do	do					0		Damage small. Passed 3 miles south of Pretty Prairie.
Do	do					0		Damage small. Passed short distance north of Pretty Prairie.
Marshall	Apr. 23	5:00 p. m.	SW	¼ to ½ mile	3	0		Storm formed over Oketo, moved into Nebraska, where 3 persons killed. Total damage was considerable in Kansas. Total damage in both States was $32,000. Total length of path in both States was 14 miles.
Stanton	Apr. 27	Shortly after noon hour.	W	100 yards	10	1	1,500	3 tornado clouds seen; storm formed in Colorado and moved across nothern part of Stanton County.
Seward and Meade	do	4:15 p. m.	NW	Wide	15	0		Damage from wind light, but much damage from accompanying hail. Passed through edge of Plains.
Morris	May 19	3:00 p. m.	SW	Narrow	7	0		Damage small. Occurred between Delavan and Wilsey.
Barber	May 22	Evening				0		Damage small. Occurred 10 miles northwest of Hazelton.
Kiowa	do	6:00 p. m	SW	600 feet	9	0	100,000	Greensburg struck; 8 persons injured.
Sedgwick	do	8:55-9:30 p. m.	SW	1 mile in places	30	0	100,000	Traveled from Clonmell to northern edge of Wichita in 35 minutes.
Ford	May 31	Evening	SW			0		Damage comparatively small. Occurred 6 miles southwest of Dodge City.
Wichita	Aug. 4	5:10 p. m.	W			0	Larg	Leoti str=ck and many buildings in town destroyed. Damage not estimated. Several persons injured.
Finney	do	6:00 p. m.	W		4	0	do	Damage severe at Garden City, but amount not estimated.
Rice	Sept. 17					0		Damage small. Occurred in southwest part of county.
Republic	Sept. 20	3:00 p. m.	SW	150 feet	6	0	$1,500	Chief damage in Belleville.
Harvey	Sept. 26	Between 7:30 and 10:30 p. m.				0		Occurred near Halstead in connection with violent thunder storm which caused $210,000 damage. Very small per cent of this due to tornado itself.
Gray	Sept. 27	5:17 p. m.	SW			0		Damage small. Occurred between Cimaron and Ingalls.
1924								
Nemaha	Mar. 3	Evening	SW		15	0		Damage amounted to several hundred dollars. Occurred between Seneca and Bern.
Harper	Mar. 28	2:30 p. m.	SW	125 yards	10	0	8,000	Most of damage at Crisfield.
Elk	do	4:30 p. m.	SW	40 feet	7	0	800	Formed near Moline.
Franklin	do	5:30 p. m.	SW			0		Considerable damage, not estimated. Originated near Pomona. No towns struck.
Brown	do	5:00 p. m.	SW		1	0		Damage small. Occurred near Hiawatha.
Wilson and Woodson	do	Evening	S	40 feet	15	0		Ended near Yates Center. Several thousand dollars damage.
Brown	June 7	5:00 p. m.	W		8	0		Several small tornadoes occurred close together; 1 near Mercier, 1 near Willis, and 1 near Baker. Probably a reappearance of same cloud. Damage small and paths short.
Montgomery, Labette, and Cherokee.	June 9	5:00-6:30 p. m.	W		50	1		Considerable damage. Occurred at Halowell and Coffeyville.
Crawford	June 20	1:00 p. m.				0		Damage small. Occurred at Arma. Path very short.
Doniphan	June 24	Between 5:00 and 6:00 p. m.	WSW	Narrow		0		2 tornadoes near Wathena. Damage light in Kansas but heavy near St. Joseph, Mo.
Ford	July 13	3:30 p. m.				0	500	Occurred 4 miles west of Dodge City. Damage small.
McPherson	do	7:00 p. m.	NW		10	0	100,000	Damage occurred chiefly at Conway, Windom, Inman, and Groveland. Tornado occurred in connection with violent thunderstorms.
Butler	do	8:15-8:45 p. m.	WNW	100 feet to 2 miles	23	1	2,000,000	Greatest destruction at Augusta and to oil rigs. Storm traveled 23 miles in 30 minutes.
Bourbon	do	9:30 p. m.	NW	200 feet	Several.	0		Damage only a few thousand dollars. Occurred at Devon. Path several miles long.
Marion	Sept. 10	Afternoon		½ mile	7	0	25,000	Occurred at Marion.
1925								
Montgomery	Mar. 18	5 a. m.	SW	3 miles	30		50,000	Greatest damage at Dearing.
Chase and Morris	Apr. 23	Between 2:00 and 3:00 p. m.	SSW	300 to 400 feet	36	0	12,000	Path extended from southwestern part of Chase County to near Dunlap, but not continuous.
Atchison	do	4:00 p. m.	W	Narrow	15	0		Damage amounted to several thousand dollars, chiefly in Atchison.
McPherson	June 1	Between 3:00 and 4:00 p. m.	SW	50 to 100 yards	15	0	65,000	Formed 2 miles south of McPherson.
Cherokee and Crawford.	do	5:00 p. m.	SW		12	0	100,000	Path ended a few miles south of Pittsburg; 4 persons injured.

County and year	Date	Hour	Storm moved from—	Width of path	Length of path (miles)	Loss of life	Property damage (estimated)	Remarks
1925—Continued								
Riley and Pottawatomie.	June 2	5:00 p. m.	SW	50 to 100 feet	10	0	$35,000	Disappeared near Garrison. Several tornado clouds seen.
Scott	June 15	Afternoon		100 feet	4	0		Damage small. Occurred near Manning.
Clay	do	Between 7:30 and 8:00 p. m.	W	200 yards	1	0	10,000	Originated 4 miles northeast of Clay Center.
Ottawa	do	8:30 p. m.	WSW	1 mile	18	0	100,000	Chief damage at Delphos.
Brown	June 17	4:00 p. m.				0		Very little damage.
Sheridan	Aug. 14	Evening				0		Damage small, mostly at Seguine.
Wyandotte	Sept. 10	4:00 p. m.	SW		1	0	5,000	Chief damage near Bethel.
1926								
Butler	May 13	2:30 p. m.	WNW	300 feet	1	0	500	Occurred near Elbing.
Barber	May 15	6:00 p. m.	SW	¼ mile	8	0	8,000	Occurred 6 miles west of Hardtner.
Jefferson	June 15	Afternoon				0		No damage. Cloud failed to touch ground. Was sighted near Grantville.
Shawnee and Jefferson	June 16	5:00 p. m.	WSW	Narrow	5	0		Damage small. Formed at eastern edge of Topeka; 2 tornado clouds seen.
Greenwood	do	5:45 p. m.				0	100,000	Occurred 12 miles north of Eureka in Thrall oil field. Damage includes that of 2 other Greenwood County tornadoes of same day, chiefly to oil rigs.
Do	do	Late afternoon				0		Occurred at Sallyards. Path short.
Do	do	do				0		Occurred near Climax. Path short.
Mitchell	June 20	Between 5:00 and 6:00 p. m.	SW		25	0		Damage small. Path extended from near Hunter to near Beloit but not continuous.
Ellsworth and Saline	do	7:30 p. m.	W	100 feet to ¼ mile	30	0	40,000	Passed 2 miles north of Ellsworth. Several pendant clouds reported.
Nemaha	do	8:00 p. m.				0	3,000	Occurred at Seneca.
Doniphan	do	8:30 p. m.		200 yards		0	1,200	Occurred at Severance.
Dickinson and Morris	July 8	9:30 p. m.	NW	160 yards	25	0	6,000	Path extended from near Abilene to near Parkerville.
Rawlins	Aug. 9	Between 8:00 and 10:00 p. m.	W		20	0	2,500	Occurred in northern part of county in connection with thunderstorms. Path not well defined.
Marshall and Nemaha	Sept. 2	6:00 p. m.	SW		10	0		Considerable damage, not estimated. Occurred in northern parts of counties.
Finney and Gray	Sept. 14	6:30 p. m.	SW			0		No damage reported. Cloud seen for about 5 minutes, only, and was 25 miles northwest of Dodge City.
Ford	do	7:15 p. m.	SW			0		Funnel cloud failed to reach ground but passed directly over Dodge City. Some damage from high winds in Dodge City.
1927								
Cloud	Mar. 11	About 5:30 p. m.	SW	50 feet	Short.	0	150	Occurred near Aurora.
Jackson	do	5:30 p. m.	SSW	100 feet	15	0	7,000	Extended from southwest of Holton to near Netawaka. Path not continuous.
Doniphan	do	8:00 p. m.	SW	150 yards	3½	0	1,500	Occurred southwest of Wathena.
Gray	Apr. 7	7:00 p. m.				0		Damage small.
Harvey	Apr. 18	1:30 p. m.	W	200 yards	½	0	600	Occurred 7 miles southwest of Newton.
Cowley	do	8:00 p. m.	SW		100 feet.	0	100	Occurred in edges of Arkansas City. Cloud dipped to earth in but one place.
Jewell	Apr. 28	3:30 p. m.	NNE	100 yards		0		Originated in Nebraska. Little damage in Kansas.
Comanche	May 7	5:00 p. m.				0		No damage; 2 tornado clouds appeared 10 miles west of Aetna. Paths not well defined.
Comanche, Barber, Kingman, Reno, and McPherson.	do	5:20–11:45 p. m.	SSW	½ to 2 miles	118	10	1,300,000	Storm struck East Hutchinson where most of damage was done; 300 persons injured. Storm pursued a zigzag path at rate of about 18 miles per hour.
Ford	May 17	Late afternoon						Occurred 3 miles east of Ensign. Damage small.
Shawnee	June 3	4:40 p. m.	WSW	100 feet	5½	0	400	Occurred in suburbs of Topeka.
Do	do	6:30 p. m.	SW		½	0	1,000	Occurred near Auburn; 2 tornado clouds seen pursuing parallel paths 100 to 150 feet apart.
Lane	June 4	Afternoon	NW	½ mile		0	50,000	Occurred in connection with thunderstorm near Shields. Path not well defined.
Jackson and Atchison	June 11	7:45 p. m.	SW	do	30	0	1,000	Damage mostly in Muscotah.
Wabaunsee and Osage	July 16	4:00–4:30 p. m.	WNW	900 feet	12	2	100,000	Extended from near Harveyville to Burlingame; 12 persons injured.
Morris, Lyon, and Coffey.	do	4:15–4:45 p. m.	WNW	A few feet to 50 yards.	28	3	100,000	Extended from near Dunlap to near Lebo. Traveled 28 miles in 30 minutes.
Johnson and Wyandotte.	do	4:45 p. m.	WSW	600 feet	4	4	160,000	Extended from Rosedale to South Park, a suburb of Kansas City; 40 persons injured.
Pratt and Barber	Aug. 13	7:00 p. m.	WNW	300 feet	10	0	10,000	Extended from near Coats to near Sawyer.
Cherokee	Oct. 2	12:15 a. m.	SW	200 yards	5	0	10,000	Occurred east of Columbus.
1928								
Smith	May 2	Between 8:00 and 8:30 p. m.	NW		5	0	15,000	Occurred in northern part of county in connection with violent thunderstorms. Path not well defined.
Doniphan	May 15	4:50 p. m.	SW	50 to 100 feet	7	0	2,000	Damage occurred at White Cloud. Storm moved into Missouri.
Rooks	June 5	6:30 p. m.	NW	300 yards	4	0	600	Occurred near Zurich.
Do	do	7:30 p. m.	NW	do	1	0	800	Originated 2½ miles east of Plainville.
Logan	June 7	Afternoon	SW			0	5,000	Originated near Elkader, 25 miles south of Oakley.
Bourbon and Crawford	June 8	3:00 a. m.	N	Narrow	15	0	5,000	Formed south of Fort Scott. Damage chiefly in Godfrey, Garland, and Croweburg.
Finney	do	Late afternoon				0	1,000	Occurred 8 miles north of Garden City.
Rawlins	June 11	7:30 p. m.	SW	600 feet to ½ mile	18	0	5,000	Originated southwest of Ludell. Moved to McCook Nebr., where much damage was done.
Logan	do	do	SW	600 feet	22	0	12,000	Formed 4 miles east of Monument.
Bourbon	do	Midnight	SW	Narrow		0	6,000	Occurred 5 miles northwest of Garland.
Rush	June 16	5:30 p. m.	NW	50 feet	15	2	5,000	Formed near Nekoma.
Saline	do	6:00 p. m.	NW	100 feet	5	0	3,000	Occurred 5 miles southwest of Solomon; 4 distinct funnels seen.
Ellsworth and Saline	do	do	WNW	100 feet to ¼ mile	8	0	51,000	Passed close to Brookville.
Rice	do	6:30 p. m.	NW	100 feet	3	0	1,500	Formed 1½ miles northeast of Alden; 4 funnel-shaped clouds sighted.
Saline	do	do	W	50 feet		0	1,000	Struck west edge of Falun. Path very short.
Stafford	do	7:00 p. m.	W	½ mile	12	0	10,000	Moved from near St. John to near Stafford. Pendant cloud larger at bottom than top.
Kiowa and Pratt	do	6:00–8:00 p. m.	WNW	300 feet to ½ mile	40	0	100,000	Moved from Greensburg to Sawyer; 3 distinct funnel-shaped clouds seen.
Lyon	June 17	3:00 p. m.	NW	200 yards	1½	0	18,000	Formed near Americus.
Wilson and Neosho	do	6:00 p. m.	SW	300 yards	12	0	20,000	Moved from near Altoona to near Chanute.
Stanton	June 19	8:30 p. m.	NW		7	0	5,000	Most of damage in Johnson.
Anderson	June 22					9		Damage small. Cloud as seen from Garnett scarcely reached the ground.
Reno	June 23	7:00 p. m.	NW	25 feet to ¼ mile	15	0		Originated 4 miles northwest of Arlington. Damage small.
Gove	do					0		Occured in southwestern part of county. Damage small.
Lane	do	Near noon	W	40 feet	Several.	0		Damage small. Occurred between Healy and Dighton.
Finney, Scott, and Lane	Oct. 11	Afternoon	SW	30 feet	20	0	20,000	Path over rural sections; crossed southern part of Scott County.

NOTES, ABSTRACTS, AND REVIEWS

Arctic ice and British weather.—For many years meteorologists have played with the idea that the weather secrets of temperate latitudes are to be sought in the frozen north. The theory of action centers suggested a mechanism by which polar ice may influence seasonal changes, and the development of the theory of the polar front showed how Arctic conditions could dominate day to day changes. After lying almost dormant for many years, the idea has lately begun to find expression in both practical and theoretical researches. Prof. W. H. Hobbs' expedition to Greenland, which had for one of its principal objects the establishment of a station on the inland ice, is one example of the practical side, and another is the recent trans-Arctic flight of Capt. Sir George Wilkins, whose program included the search for sites on which permanent meteorological stations could be established. On the theoretical side reference has been made in a previous number of the Meteorological Magazine [1] to the work of W. Wiese, but this is naturally concerned more with the weather of Russia than with that of western Europe.

A statistical investigation of the influence of Arctic ice on the pressure distribution over western Europe

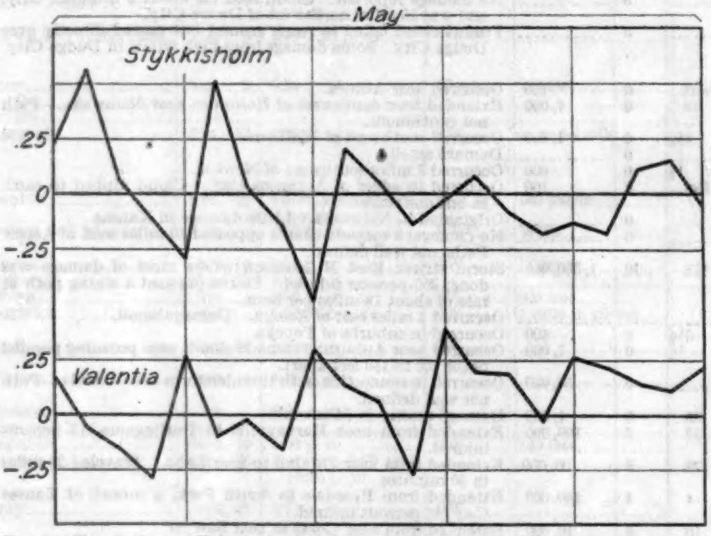

FIG. 1.—Correlation coefficients; ice index figures and the quarterly pressure during the following five years

which has recently been published as a Geophysical Memoir [2] shows that the matter is sufficiently complicated, the influence varying with the season in a way which suggests that it is due to a combination of several factors, some acting in one direction, some in another. As a result, the correlation coefficients obtained, while sometimes appreciable, are never high, though they are sufficiently confirmed by various checks to show that they are real.

The area dealt with in the Arctic is divided into four parts, the neighborhood of Iceland and Greenland, Barents, and Kara Seas. The ice conditions in these areas in spring and summer are known mainly from the annual survey of the Danish Meteorological Institute,[3] and these ice figures were correlated with quarterly means of pressure at nine selected stations covering an area from Jacobshavn (Greenland) and Vardo (Norway) in the north to Ponta Delgada in the south and Berlin in the east. As a result, three relationships were found, the first two of which were suspected before, while the third appears to be not only new, but surprising:

(1) When there is much ice in the Arctic, pressure in spring and summer tends to be above normal in the northwest (Jacobshavn, Stykkisholm and Thorshavn) and below normal in the southwest (Ponta Delgada).

(2) When there is much ice in the Arctic in the spring and summer, pressure in the following late autumn and winter (November to January) tends to be below normal over the British Isles and northern France.

(3) Similar effects tend to recur annually at northern stations for about four years following abnormal ice years. (See fig. 1.)

The memoir in question is concerned more with the presentation of facts than with the discussion of their causes, but the third result was sufficiently curious to arouse speculation. It must first be remarked that there are two chief ways in which Arctic ice may affect the distribution of pressure. In the first place ice and ice-cold water cool the air above, and since cold air is heavy, the presence of a large cold area tends to raise the barometric pressure in its neighborhood. On the other hand, the Icelandic low is generally regarded as intimately related to the general circulation of the atmosphere, so that when this circulation is vigorous, pressure at Stykkisholm is below normal. The atmospheric circulation is in turn related to the temperature difference between poles and Equator, so that much ice in the Arctic, by increasing this temperature difference, should lower the pressure at Stykkisholm. Thus there are two opposing tendencies, one toward a higher pressure and the other toward a lower pressure at Stykkisholm in years of much Arctic ice, and it may well be that the first tendency prevails at one season, the second at another. Let us see how they may operate.

Dealing first with the tendency for much ice to raise pressure, it appears that the relatively small amounts of ice which appear off Iceland in spring and early summer are not likely themselves to have a great effect. It is when they begin to melt and to cover the surface of the northernmost Atlantic with a thin sheet of cold thaw water, that we should expect the effect to be most noticeable. The greater part of the break up of ice from the East Greenland Current takes place in summer, and it is in this season that we should look for the greatest tendency for much Arctic ice to raise pressure near Stykkisholm. On the other hand, we should expect the effect on the general atmospheric circulation to be greatest in January to March, when the ice in the Arctic basin itself is most solid and extensive. Moreover the Icelandic low is intense in winter, feeble in summer, and for both these reasons we may anticipate that the tendency for much Arctic ice to lower pressure over Iceland will be greatest in winter.

We come next to the recurrence of similar tendencies at the same season in several successive years. That this is real is shown by Figure 1, reproduced from the original memoir, showing the correlation coefficients between an "ice index" figure obtained by combining the ice data from Greenland, Barents and Kara Seas, and the quarterly pressures at Stykkisholm and Valentia during the following five years. It is not until the fourth or fifth year that the regular recurrence of positive and negative coefficients breaks down. There can be little doubt that this recurrence is due to the persistence of the main mass of Palæocrystic ice, of which the variable ice areas in the

[1] Vol. 61, 1926, p. 29.
[2] The influence of Arctic ice on the subsequent distribution of pressure over the eastern North Atlantic and western Europe. By. C. E. P. Brooks and Winifred A. Quennell. London. Meteor. Office. Geophys. Memoirs No. 41.
[3] Isforholdene i de Arktiske Have. Copenhagen, Dansk Meteor. Institut.

outlying seas are merely the fringes. The Palæocrystic ice is believed to form mainly to the north of Siberia, whence it drifts slowly across the Arctic Ocean, part of it finally reaching the East Greenland Current. The passage across the Arctic takes about four years, so that if a large amount of ice is formed north of Siberia in any one year, we may look for its effects during the following four years. Each summer it sheds some ice from its fringes, and the thaw water brings high pressure to Iceland, while each winter it strengthens the atmospheric circulation and deepens the Icelandic low.

The tendency to low pressure at Valentia which recurs each autumn after much Arctic ice may be tentatively attributed to storminess resulting from the introduction of streams and patches of cold thaw water into the warm Gulf Stream Drift of the North Atlantic. The same phenomenon is observed, though less definitely, in the winter following a year with much ice off Newfoundland, an effect which is also investigated in the memoir, but with the Newfoundland ice there is very little if any recurrence in the second year.—*C. E. P. Brooks.*

Two cold winters coming in France?—Director H. Memery, Observatoire de Talence (Gironde) has for some time been publishing discussions on the apparent effect of sun spots on the weather. His latest paper, Les Variations Solaires font Prévoir des Hivers Froids en 1929 et en 1930,[1] presents two points on sun spot weather relationships. The first is that since 9 sun spot periods equal 100 years, we should expect to find much the same sequence in sun spot numbers by seasons and, if sun spots control weather, likewise the same general sequence of seasonal abnormalities now as occurred just 100 years ago. M. Memery draws a comparison of 13 of the seasonal abnormalities of 1788–1828 with those of corresponding years 1888–1928, and shows a similarity so marked as to lead him to believe that the cold winter of 1829 and the rigorous winter of 1830 are likely to indicate that his next two winters, 1928–29 and 1929–30 will be cold. He refrains from making a definite forecast to this effect, however.

The other point in his discussion is on the question, if sun spots control the weather to this extent, why is there not similar weather every 11 years? This he seeks to answer by pointing out that the sun spots do not increase and decrease uniformly but change irregularly, there rarely being increases or decreases lasting as much as six months in the same direction. While he associates high summer temperatures, such as those of 1928, with increasing sun spots at high numbers, he indicates that this combination of solar conditions in the summer months does not occur during every sun-spot maximum. He believes that the great solar activity in August, 1928, marked the peak of the present sun spot cycle and that decreasing solar activity this winter is likely and that it may bring low winter temperatures in its train.—*C. F. B.*

Auroral observations of the "Maud" expedition.—"Aurora Photographs" is the title of a paper by Ragnvald Wesøe representing No. 6 of volume 1 of the scientific results of the Norwegian north polar expedition with the *Maud*, 1918–1925, published in Bergen, 1928. The positions of auroral arches over the Arctic Sea north of eastern Siberia when mapped in conjunction with those farther west, and particularly over Scandinavia form arcs of a circle centering in northwest Greenland. The monograph contains especially fine photographs of the aurora. Assuming the basal height to have been 110 kilometers two of the tops of streamers measured were below 150 kilometers, three under 200 kilometers, and only one reached an elevation of 288 kilometers.

[1] Bull. de l'Observatoire de Talence (Gironde) 2e ser. no. 4, Oct. 15, 1928, p. 17–20.

The other parts of the scientific results of the *Maud* expedition that have been published are: Results of Astronomical Observations on the Properties of Sea Ice; Magnetic, Atmospheric-Electric, and Auroral Results; The Wind-Drift of the Ice on the North Siberian Shelf.—*C. F. B.*

Conduction of heat through sea ice.—The late Dr. Finn Malmgren, who so lamentably met his death on the sea ice after the crash of the *Italia*, made a most thorough investigation on the properties of sea ice while on the *Maud*. A monograph containing his results has been published (Bergen, 1927) as No. 5 of volume 1 of the Scientific Results of the Norwegian North Polar Expedition with the *Maud*. Of interest to meteorologists is his computation of the heat that is conducted through the polar ice covering to the atmosphere during the colder months—7,670-gram calories per square centimeter from September to April. This is one-ninth of the heat discharge by the Mediterranean as measured by Aimé. It is enough, however, to raise the temperature of the lowest 150 meters, the cold layer of air over the polar sea by 6.9° C. in one day. Doctor Malmgren concludes:

> The great acquisition of heat by the atmosphere above the Polar Sea during the winter via the ice from the warm water of the sea greatly contributes to diminish the cold of winter and explains the fact that, despite the clear winter sky and the calm weather, we have over the Polar Sea considerably milder winter temperatures than farther south over the continent of Asia.[1]
>
> —*C. F. B.*

Rainfall of Australia.—The rainfall map of Australia for 1927, published by the Commonwealth Bureau of Meteorology of that country, has just come to hand. Among other interesting information it shows the areas of the Commonwealth that have had more than the average rainfall for each year since 1908. The statistics are reproduced in the table below and it is to be noted that there is little correspondence between the rainfall in that country and the United States of North America, for example. The year 1910 in Australia was a year of generally abundant rains, yet it was one of the driest ever experienced in the United States; 1917 was much the same, but 1916 was a year of rather generous rains both in the United States and Australia.

TABLE NO. 1.—*Per cent of area in Australia having greater than average rainfall*

Year	Per cent	Year	Per cent	Year	Per cent
1908	33	1915	26	1922	21
1909	40	1916	60	1923	22
1910	75	1917	75	1924	27
1911	25	1918	28	1925	24
1912	12	1919	13	1926	21
1913	27	1920	54	1927	34
1914	11	1921	63		

Retirement of Mr. J. H. Field as director-general of Indian meteorological observatories.—We learn from the report on the administration of the meteorological department of the Government of India for 1927–28 that Mr. J. H. Field was retired from service in March, 1928, under the superannuation rule. Mr. Field, who joined the meteorological department, in 1904 will be remembered for the very large part that he took in the development of upper-air research in India, a problem that occupied the greater part of his service in that country; he was also responsible for the creation of the upper-air observatory at Agra in 1914, and but recently proposed a method of forecasting the winter rainfall of northern India from upper-air data. He was succeeded as director-general by Mr. C. W. B. Normand.—*A. J. H.*

[1] Cf. H. U. Sverdrup: The North-Polar Cover of Cold Air. Mo. Weath. Rev., 1928, 56: 53.

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RECENT ADDITIONS

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SOLAR OBSERVATIONS

By HERBERT H. KIMBALL, Solar Radiation Investigations

SOLAR AND SKY RADIATION MEASUREMENTS DURING OCTOBER, 1928

For a description of instruments and exposures and an account of the method of obtaining and reducing the measurements, the reader is referred to the REVIEW for January, 1924, 52:42; January, 1925, 53:29, and July, 1925, 53:318.

Table 1 shows that solar radiation was below its normal intensity for October at Washington, D. C., and Lincoln, Nebr., and above at Madison.

Table 2 shows an excess in the total radiation received on a horizontal surface at Washington, and a deficiency at Madison and Lincoln.

Measurements of the percentage of skylight polarization made on seven days at Washington give a mean of 50 per cent, with a maximum of 56 per cent on the 10th. These are below the corresponding averages for October at Washington. At Madison, measurements made on six days give a mean of 69 per cent, with a maximum of 77 per cent on the 5th. These are above the corresponding averages for October at Madison.

TABLE 1.—*Solar radiation intensities during October, 1928*

[Gram-calories per minute per square centimeter of normal surface]

Washington, D. C.

Date	Sun's zenith distance										
	8 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass A. M.					Air mass P. M.				Local mean solar time
	e.	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Oct. 1	7.57			0.73							7.57
Oct. 3	9.14				1.00	1.31					10.97
Oct. 6	9.14		0.95	1.10	1.26	1.50	1.29	1.12	1.01	0.92	7.04
Oct. 8	6.02			0.68	0.96	1.10	0.99	0.75	0.63	0.55	7.57
Oct. 10	9.83	0.78		1.00	1.18	1.38	1.15	0.90	0.77		7.57
Oct. 11	9.47	0.66	0.78	0.91	1.14		1.16	1.00	0.86	0.72	9.14
Oct. 12	10.21	0.74	0.86	1.00	1.18	1.34	1.22	0.99			13.13
Oct. 13	10.97				1.08						10.97
Oct. 20	5.79	0.60	0.76	0.91	1.12						5.36
Oct. 24	5.56	0.47	0.60	0.79	1.02						5.56
Oct. 25	5.36	0.72	0.77	0.95	1.19						4.17
Oct. 26	5.16	0.74	0.86	0.94	1.14						4.17
Means		0.67	0.80	0.90	1.12	1.33	1.16	0.95	0.82	0.73	
Departures		−0.09	−0.04	−0.04	+0.01	−0.09	+0.05	+0.02	+0.02	+0.03	

[1] Extrapolated.

TABLE 1.—*Solar radiation intensities during October, 1928*—Contd.

Madison, Wis.

Date	Lun's zenith distance										
	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass									Local mean solar time
		A. M.					P. M.				
	e.	5.0	4.0	3.0	2.0	1.0	2.0	3.0	4.0	5.0	e.
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
Oct. 2	6.27						1.10				6.02
Oct. 3	7.57				0.92						11.81
Oct. 5	8.18					1.51	1.32	1.16			6.76
Oct. 9	6.50	0.94	1.04	1.14	1.28	1.53					4.95
Oct. 24	4.95		0.99	1.11	1.22		1.25				4.95
Oct. 25	4.75	1.00	1.11	1.21	1.35	1.50					4.75
Oct. 29	2.62	0.99	1.12	1.25	1.39						2.26
Means		0.98	1.06	1.18	1.23	1.51	1.22	1.16			
Departures		+0.20	+0.12	+0.12	+0.04	+0.11	+0.03	+0.14			

Lincoln, Nebr.

Date	8 a.m.	5.0	4.0	3.0	2.0	1.0	2.0	3.0	4.0	5.0	Noon
Oct. 2	4.95					1.33	1.12	0.94	0.79	0.66	5.56
Oct. 3	8.48					1.29	1.07	0.92	0.77	0.66	9.14
Oct. 5	6.27		0.68	1.01	1.28	1.54	1.27	1.06	0.93	0.81	4.57
Oct. 6	6.27	0.65	0.74		1.08						3.99
Oct. 8	11.38			1.02							6.04
Oct. 9	6.27	0.84	0.87	1.03	1.21	1.53					5.78
Oct. 18	5.94			0.83	1.22						5.56
Oct. 19	4.57	0.97	1.07	1.20	1.36	1.53	1.30	1.03	0.95	0.76	4.95
Oct. 20	5.56				1.25						6.50
Oct. 22	4.17	1.00	1.12	1.25	1.39	1.56					2.49
Oct. 23	7.04								0.98	0.93	4.75
Oct. 26	5.36						1.02				5.56
Oct. 27	4.95				1.18	1.51	1.21	1.01		0.84	6.02
Means		0.86	0.90	1.06	1.25	1.47	1.16	0.99	0.88	0.78	
Departures		−0.02	−0.05	−0.04	−0.03	−0.02	−0.09	−0.09	−0.07	−0.06	

TABLE 2.—*Solar and sky radiation received on a horizontal surface*

[Gram-calories per square centimeter of horizontal surface]

Week beginning—	Average daily radiation						Average daily departure from normal		
	Washington	Madison	Lincoln	Chicago	New York	Twin Falls	Washington	Madison	Lincoln
1928	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
Oct. 1	345	297	349	275	271	452	+19	+28	+21
Oct. 8	348	227	241	200	233	336	+53	−23	−67
Oct. 15	243	140	258	113	180	390	−29	−81	−45
Oct. 22	316	190	311	127	163	402	+53	−15	+42
Excess or deficiency since first of year on Oct. 28							−1,829	+339	−863

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. C. S. Freeman, Superintendent U. S. Naval Observatory. Data furnished by Naval Observatory, in cooperation with Harvard, Yerkes, and Mount Wilson Observatories. The differences of longitude are measured from central meridian, positive west. The north latitudes are plus. Areas are corrected for foreshortening and are expressed in millionths of sun's visible hemisphere. The total area, including spots and groups, is given for each day in the last column]

Date	Eastern standard civil time	Heliographic			Area		Total area for each day
		Diff. long.	Longitude	Latitude	Spot	Group	
1928	h. m.	°	°	°			
Oct. 1 (Naval Observatory).	15 12	−9.0	31.7	+18.5		123	
		+2.5	43.2	−16.0		93	
		+56.0	96.7	−18.0		463	
		+64.0	104.7	−14.5		525	1,204
Oct. 2 (Yerkes)	9 31	+0.5	31.0	+20.0		100	
		+11.9	42.4	−16.7		75	
		+62.5	93.0	−15.0		100	
		+66.0	96.5	−19.5		200	
		+73.0	103.5	−13.0		300	
		+75.0	105.5	−15.5		300	1,075
Oct. 2 (Naval Observatory).	12 17	−63.5	325.6	−15.0	31		
		−60.5	328.6	+16.0	31		
		+2.0	31.1	+19.5		77	
		+13.5	42.6	−16.5		93	
		+64.5	93.6	−15.0	62		
		+68.5	97.6	−20.0		247	
		+76.0	105.1	−14.5		432	973

Positions and areas of sun spots—Continued

Date	Eastern standard civil time	Heliographic			Area		Total area for each day
		Diff. long.	Longitude	Latitude	Spot	Group	
	h. m.	°	°	°			
Oct. 3 (Yerkes)	9 43	−82.6	294.5	+14.5		200	
		−75.0	302.1	+14.5		250	
		+12.8	29.9	+19.8		75	
		+25.6	42.7	−17.1		40	
		+75.8	92.9	−14.0		100	
		+79.3	96.4	−19.0		300	965
Oct. 3 (Naval Observatory).	11 35	−83.5	292.8	+14.0	123		
		−75.5	300.8	+14.0	154		
		−50.0	326.3	−14.5	15		
		−49.0	327.3	+11.5		77	
		+14.0	30.3	+20.0		77	
		+27.0	43.3	−16.5		77	
		+77.0	93.3	−15.0	77		
		+80.5	96.8	−20.0	231		831
Oct. 4 (Naval Observatory).	11 28	−69.5	293.7	+13.5	139		
		−61.5	301.7	+14.0	262		
		−36.5	326.7	−15.0	15		
		−35.5	327.7	+11.5		62	
		+24.5	27.7	+20.0		93	
		+39.0	42.2	−17.5	15		586
Oct. 5 (Naval Observatory).	11 33	−78.5	272.5	−4.5		154	
		−56.5	294.5	+13.0	123		
		−48.5	302.5	+13.5	170		
		−24.5	326.5	−16.0	15		
		+56.5	47.5	−16.0	15		477
Oct. 6 (Yerkes)	9 25	−77.3	260.8	+18.0		200	
		−43.6	294.5	+13.4		75	
		−35.5	302.6	+13.9		150	425
Oct. 6 (Naval Observatory).	11 44	−77.0	259.7	+17.5	154		
		−64.0	272.7	−5.0		93	
		−44.0	292.7	+12.5		123	
		−34.5	302.2	+13.5	154		
		+68.0	44.7	−17.0		62	586
Oct. 7 (Yerkes)	9 41	−75.4	249.2	+8.7		100	
		−64.0	260.6	+17.9		200	
		−30.5	294.9	+13.0		50	
		−22.7	301.9	+13.7		150	500
Oct. 7 (Naval Observatory).	11 37	−77.5	246.0	+7.5		262	
		−63.5	260.0	+18.0	185		
		−50.5	273.0	−5.0		62	
		−29.0	294.5	+12.5		139	
		−24.0	299.5	+18.5		31	
		−21.5	302.0	+13.0	154		
		−6.5	317.0	−14.0		62	895
Oct. 8 (Naval Observatory).	11 38	−67.5	242.8	+6.5	93		
		−61.0	249.3	+9.0	123		
		−51.0	259.3	+18.5	185		
		−36.0	274.3	−5.0		46	
		−16.0	294.3	+12.0		154	
		−8.5	301.8	+13.5	170		
		+9.0	319.3	−14.5		62	
		+37.0	347.3	−16.5	31		864
Oct. 8 (Yerkes)	13 31	−64.7	244.6	+7.2		100	
		−58.6	250.7	+10.2		60	
		−48.1	261.2	+19.2		200	
		−14.5	294.8	+13.5		50	
		−6.6	302.7	+14.0		300	710
Oct. 9 (Yerkes)	11 20	−53.5	243.5	+6.9		300	
		−46.5	250.5	+9.7		40	
		−38.4	258.6	+18.5		200	
		−2.8	294.2	+13.2		50	
		+4.9	301.9	+14.0		250	840
Oct. 9 (Naval Observatory).	11 43	−52.0	245.1	+8.0		370	
		−38.0	259.1	+18.0	154		
		−21.0	276.1	−5.0		62	
		−3.0	294.1	+12.0		123	
		+5.0	302.1	+13.0	139		848
Oct. 10 (Yerkes)	10 11	−41.4	243.1	+6.9		400	
		−34.8	249.7	+9.7		150	
		−25.3	259.2	+18.7		250	
		+9.7	294.2	+13.2		60	
		+17.3	301.8	+14.0		275	1,135
Oct. 10 (Naval Observatory).	11 42	−40.5	243.4	+6.5	370		
		−35.0	248.9	+8.5		185	
		−24.5	259.4	+18.5	154		
		−14.0	269.9	+10.0		62	
		−10.5	273.4	−5.0	15		
		+11.5	295.4	+11.5		123	
		+18.5	302.4	+13.0	123		
		+67.0	350.9	+2.0		93	1,125
Oct. 11 (Yerkes)	10 3	−29.2	242.5	+6.8		500	
		−21.8	249.9	+9.8		175	
		−12.2	259.5	+18.7		275	
		+23.1	294.8	+13.2		50	
		+30.5	302.2	+13.9		250	1,250

Positions and areas of sun spots—Continued

Date	Eastern standard civil time		Heliographic			Area		Total area for each day
			Diff. long.	Longitude	Latitude	Spot	Group	
	h.	m.	°	°	°			
Oct. 11 (Naval Observatory).	11	45	−45.0	225.7	−7.5		31	
			−28.0	242.7	+6.5		478	
			−20.5	250.2	+10.0	123		
			−11.5	250.2	+18.5	123		
			0.0	270.7	+10.0		77	
			+5.0	275.7	−5.0		31	
			+24.5	295.2	+12.0		93	
			+31.5	302.2	+13.0	123		
			+82.5	353.2	+2.0	62		1,141
Oct. 12 (Naval Observatory).	11	43	−34.0	223.5	−8.0	15		
			−16.0	241.5	+6.5		293	
			−9.0	248.5	+8.5		216	
			−8.0	249.5	−16.5		15	
			+1.5	259.0	+18.5	123		
			+14.5	272.0	+9.0		77	
			+37.5	295.0	+12.5	46		
			+45.0	302.5	+13.0	123		908
Oct. 13 (Naval Observatory).	11	45	−81.5	162.8	−18.0	123		
			−2.5	241.8	+6.0		293	
			+5.0	249.3	+8.0		170	
			+5.5	249.8	−16.5		15	
			+14.5	258.8	+19.0	123		
			+28.0	272.3	+9.0		108	
			+50.0	294.3	+12.5		62	
			+59.0	303.3	+13.5	123		1,017
Oct. 14 (Harvard)	13	56	−63.0	167.0	−18.0	26		
			−14.0	216.0	+14.0		342	
			+18.0	248.0	+7.0		552	
			+31.0	261.0	+18.5	216		
			+44.5	274.5	+9.0		36	
			+73.5	303.5	+13.5		240	1,412
Oct. 15 (Yerkes)	9	12	−84.0	135.0	+16.8		250	
			+23.5	242.5	+6.7		400	
			+32.7	251.7	+9.7		125	
			+39.8	258.8	+18.7		250	1,025
Oct. 15 (Harvard)	14	7	−78.5	138.0	+18.0	264		
			−53.5	163.0	−16.5		121	
			−1.5	215.0	+10.5	29		
			+30.0	246.5	+8.0		451	
			+42.0	259.0	+20.0	239		
			+58.0	274.5	+8.5		21	
			+72.5	289.0	+14.5		25	1,150
Oct. 16 (Naval Observatory).	12	1	−68.0	136.6	+16.5	201		
			−41.0	163.6	−17.5		77	
			+16.5	221.1	+12.5		123	
			+38.0	242.6	+6.5		201	
			+47.5	252.1	+10.0		46	
			+55.0	259.6	+19.0	123		771
Oct. 17 (Naval Observatory).	11	54	−68.0	123.5	−7.5	15		
			−63.0	128.5	+15.0		154	
			−57.0	134.5	−11.0	15		
			−55.0	136.5	+16.5	216		
			−29.0	162.5	−18.0		31	
			+32.0	223.5	+12.5		278	
			+51.5	243.0	+6.5		108	
			+61.0	252.5	+9.0		46	
			+68.5	260.0	+19.0	123		986
Oct. 18 (Naval Observatory).	11	12	−49.5	129.2	+15.0		139	
			−42.5	136.2	−9.5		31	
			−41.5	137.2	+16.5	201		
			−13.0	165.7	−17.0	31		
			+46.5	225.2	+12.5		309	
			+65.0	243.7	+6.5		62	
			+81.0	259.7	+19.5	123		896
Oct. 19 (Yerkes)	11	6	−36.3	126.9	+16.2		100	
			−25.4	137.8	+16.6		300	
			−22.4	140.8	+14.0		150	
			+62.7	225.9	+12.8		200	750
Oct. 19 (Naval Observatory).	11	52	−34.0	131.2	+13.5		170	
			−27.5	137.7	+15.0	185		
			−27.5	137.7	−10.0		62	
			−18.0	147.2	+8.0	15		
			+1.5	166.7	−18.5	15		
			+59.5	224.7	+12.0		309	
			+76.5	241.7	+6.5	46		802
Oct. 20 (Yerkes)	9	4	−16.1	137.0	+13.9		100	
			−15.1	138.0	+16.5		250	
			−11.2	141.9	+13.8		75	
			+72.2	225.3	+13.3		200	625
Oct. 20 (Naval Observatory).	11	40	−35.0	117.0	−11.0		46	
			−20.0	132.0	+13.5		154	
			−13.5	138.5	+15.5	247		
			−12.0	140.0	−9.5		31	
			−6.5	145.5	+9.0	31		
			+74.0	226.0	+12.5		185	694
Oct. 21 (Naval Observatory).	11	38	−15.0	123.9	−9.0	15		
			−12.5	126.4	+14.5		201	
			−0.5	138.4	+15.0		262	
			+3.5	142.4	−9.5	15		
			+8.5	147.4	+9.5	31		524
Oct. 21 (Yerkes)	13	2	−15.9	122.2	+17.5		50	
			−12.2	125.9	+16.2		200	
			−0.2	137.9	+16.5		300	
			+0.2	138.3	+13.8		60	610
Oct. 22 (Naval Observatory).	11	41	−1.5	124.1	−9.0	31		
			+1.0	126.6	+15.0		247	
			+13.0	138.6	+15.0		401	
			+17.0	142.6	−9.5	31		710
Oct. 23 (Yerkes)	14	54	−68.7	41.8	−13.1		100	
			−63.4	47.1	−11.0		309	
			+11.0	121.5	+17.1		60	
			+15.9	126.4	+16.4		200	
			+27.4	137.9	+16.7		250	910
Oct. 24 (Yerkes)	10	25	−57.0	42.8	−12.5		150	
			−51.9	47.9	−10.8		300	
			+27.3	127.1	+16.1		150	
			+37.9	137.7	+14.2		25	
			+39.6	139.4	+14.1		25	
			+38.8	138.6	+16.5		200	850
Oct. 24 (Naval Observatory).	11	42	−63.0	36.2	+18.0		62	
			−53.5	45.7	−10.5		278	
			+27.5	126.7	+15.5		231	
			+39.5	138.7	+14.5		324	895
Oct. 25 (Yerkes)	10	43	−43.0	43.4	−12.5		150	
			−37.9	48.5	−10.3		200	
			+41.0	127.4	+15.7		175	
			+51.7	138.1	+14.2		5	
			+52.5	138.9	+16.4		225	
			+53.5	139.9	+14.1		60	815
Oct. 25 (Naval Observatory).	11	40	−38.0	48.1	−10.5		247	
			+29.0	115.1	−8.5		31	
			+41.5	127.6	+15.5		154	
			+52.5	138.6	+15.0		216	648
Oct. 26 (Yerkes)	10	9	−24.5	49.2	−9.5		275	
			+53.9	127.6	+15.9		200	
			+65.2	138.9	+16.8		250	725
Oct. 26 (Naval Observatory).	11	41	−25.0	47.9	−10.5		185	
			+42.0	114.9	−8.5		31	
			+60.0	132.9	+14.5		340	556
Oct. 27 (Naval Observatory).	10	38	−12.5	47.8	−10.5		201	
			+67.0	127.3	+13.5	108		
			+79.0	139.3	+15.0	123		432
Oct. 28 (Naval Observatory).	13	7	−36.5	9.2	−13.5		31	
			+3.0	48.7	−10.0		201	
			+81.0	126.7	+14.0	93		325
Oct. 29 (Yerkes)	10	15	+15.1	49.2	−9.5		250	250
Oct. 29 (Naval Observatory).	11	38	−23.0	10.4	−13.5		31	
			+15.5	48.9	−10.0		170	201
Oct. 30 (Yerkes)	10	20	−78.8	300.6	+15.2		100	
			+28,5	49.1	−9.6		200	300
Oct. 30 (Naval Observatory).	11	41	−79.0	301.1	+13.0	93		
			−62.5	317.6	+12.5	15		
			−9.0	11.1	−15.5		46	
			+29.5	49.6	−10.0		139	
			+35.0	55.1	+19.0		31	324
Oct. 31 (Naval Observatory)	11	39	−66.5	300.5	+14.5	93		
			−48.5	318.5	+14.0	15		
			−33.0	334.0	+14.5		31	
			+4.0	11.0	−15.5		62	
			+42.5	49.5	−10.0	123		
			+49.5	56.5	+17.5		62	386
Mean daily area for October								773

PROVISIONAL SUN SPOT RELATIVE NUMBERS FOR OCTOBER, 1928

[Data furnished by Prof. A. Wolfer, University of Zurich, Switzerland]

October, 1928	Relative numbers	October, 1928	Relative numbers	October, 1928	Relative numbers
1	16	11	92	21	
2	69	12	71	22	
3	58	13		23	76
4	45	14	79	24	74
5	42	15	70	25	65
6	25	16	80	26	30
7	41	17	74	27	22
8	56	18	73	28	28
9	52	19	46	29	22
10	67	20	62	30	
				31	48

Number of observations, 27; mean, 56.7.

AEROLOGICAL OBSERVATIONS

By L. T. SAMUELS

Free-air temperatures were mostly above normal for October. (See Table 1.) Negative departures occurred, however, at practically all levels at Ellendale and above the 2,000-meter level at Royal Center.

Relative humidity departures were small and in general of opposite sign to those for temperature.

Vapor pressure departures were mostly positive, as might be expected from the supernormal monthly temperatures.

Free-air resultant winds for the month showed an excess of southerly component at those stations having positive temperature departures, and vice versa. (See Table 2.)

It is interesting to note the unusually large diurnal rise in surface temperature at Ellendale on the 10th. From a morning minimum of 2° C. (36° F.) the surface temperature rose to 28° C. (82° F.) by 4 p. m. A kite flight which was started at 9:30 a. m. shows a rise in temperature from 12° C. (54° F.) at the surface, to 23° C. (73° F.) at 500 meters above. It is often possible to form a fairly accurate estimate of the maximum surface temperature from the temperature lapse rate occurring in the morning by assuming a fairly high lapse rate between the surface and the top of the inversion level. Thus the temperature at 500 meters in the present case was 23° C., and now, if we assume the adiabatic lapse rate for dry air between this altitude and the surface by mid-afternoon (which is quite likely), we obtain a surface temperature of 28° C., or, as happened in the present case, the actual maximum at the surface that day.

Unusually dry air aloft was revealed by the Due West kite record of the 19th. Relative humidities between 8 and 20 per cent were recorded from 1,500 to 4,300 meters, the maximum height reached. This extreme dryness was associated with a high pressure area moving in from the west. That this dryness was of wide extent was shown by the following morning map, which indicated clear weather at practically every station east of the Mississippi and south of the Great Lakes.

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during October, 1928*

TEMPERATURE (°C.)

Altitude m. s. l.	Broken Arrow, Okla. (233 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center, Ind. (225 meters)		[1] Washington, D. C. (7 meters)	
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal
Meters												
Surface	18.0	+1.1	16.6	0.0	7.3	+0.1	20.2	+1.2	13.5	+0.4	17.9	+2.9
250	18.0	+1.2	16.4	+0.1			19.9	+1.1	13.4	+0.4	15.8	+2.0
500	17.6	+1.8	15.1	+0.4	7.1	-0.2	19.3	+1.4	12.6	+0.8	14.5	+1.6
750	16.9	+2.1	14.2	+0.7	6.7	-0.6	18.1	+1.3	11.4	+0.9	13.5	+1.8
1,000	15.8	+2.0	13.2	+0.8	5.9	-0.7	16.9	+1.2	9.9	+0.6	12.4	+2.0
1,250	14.7	+1.9	12.3	+1.0	5.3	-0.5	16.1	+1.3	8.7	+0.6	11.3	+2.1
1,500	13.6	+1.8	11.5	+1.2	4.5	-0.5	15.0	+1.3	7.4	+0.6	10.2	+2.2
2,000	11.3	+1.7	9.9	+1.4	2.0	-0.8	13.1	+1.6	4.3	0.0	7.8	+2.0
2,500	8.4	+1.4	7.4	+0.9	-0.7	-1.0	10.7	+1.5	1.9	-0.1	5.5	+1.6
3,000	5.8	+1.6	4.8	+0.6	-3.6	-1.1	8.3	+1.4	-0.7	-0.2	3.8	+1.8
3,500	3.7	+2.2	2.1	+0.6	-6.4	-1.1	4.9	+0.4	-3.4	-0.4	1.8	+2.1
4,000	0.7	+2.0	-1.1	+0.3	-8.6	-0.6	2.5	+0.6	-6.6	-0.9		
4,500			-4.4	-0.2	-9.8	+1.0	1.5	+2.3	-9.6	-1.0		
5,000							1.5	+4.3	-11.6	-0.6		

RELATIVE HUMIDITY (%)

Altitude m. s. l.	Broken Arrow Mean	Departure	Due West Mean	Departure	Ellendale Mean	Departure	Groesbeck Mean	Departure	Royal Center Mean	Departure	Washington Mean	Departure
Surface	69	+2	73	+9	62	-6	80	+6	72	+3	72	0
250	68	+1	73	+9			79	+7	72	+3	73	+4
500	61	-2	73	+10	61	-5	75	+6	68	+2	70	+4
750	56	-5	70	+8	56	-5	72	+4	67	+2	68	+2
1,000	55	-4	68	+7	54	-5	68	+2	66	+3	65	-1
1,250	54	-3	64	+4	52	-5	63	0	65	+4	65	-2
1,500	53	-2	59	+2	50	-4	61	0	66	+8	62	-4
2,000	48	-2	52	+2	48	-3	53	-2	69	+15	60	-3
2,500	44	-2	48	+3	45	-4	43	-6	58	+9	56	-1
3,000	40	-3	45	+2	47	0	41	-2	54	+8	39	-9
3,500	41	-1	41	0	44	-3	48	+7	55	+10	27	-17
4,000	25	-11	42	+1	47	+1	31	-9	54	+11		
4,500			47	+5	43	-2	17	-23	56	+13		
5,000							8	-29	46	+12		

VAPOR PRESSURE (mb.)

Altitude m. s. l.	Broken Arrow Mean	Departure	Due West Mean	Departure	Ellendale Mean	Departure	Groesbeck Mean	Departure	Royal Center Mean	Departure	Washington Mean	Departure
Surface	14.73	+1.56	14.66	+1.91	6.23	-0.72	19.49	+2.68	11.58	+0.91	15.58	+2.70
250	14.60	+1.53	14.49	+1.93			18.95	+2.79	11.54	+0.98	14.03	+2.43
500	12.93	+1.21	13.41	+2.11	6.02	-0.81	17.20	+2.62	10.42	+1.06	12.40	+1.92
750	11.35	+0.75	12.20	+1.87	5.19	-1.11	15.28	+1.89	9.57	+1.16	11.34	+1.62
1,000	10.28	+0.59	11.07	+1.54	4.68	-1.08	13.33	+1.22	8.64	+1.07	10.09	+1.15
1,250	9.42	+0.63	9.76	+1.17	4.33	-0.89	11.78	+0.99	7.64	+0.90	9.35	+1.09
1,500	8.52	+0.59	8.34	+0.85	4.03	-0.68	10.71	+1.06	6.92	+0.98	8.11	+0.71
2,000	6.45	+0.36	6.36	+0.70	3.41	-0.48	8.29	+0.98	5.66	+0.99	6.71	+0.75
2,500	4.80	+0.15	4.95	+0.54	2.76	-0.43	5.99	+0.46	3.93	+0.35	5.46	+0.74
3,000	3.69	+0.13	3.96	+0.40	2.33	-0.25	4.95	+0.81	2.91	+0.06	3.01	-0.24
3,500	3.07	+0.29	3.43	+0.50	1.91	-0.21	4.68	+1.37	2.40	+0.03	1.51	-0.78
4,000	1.73	-0.19	2.92	+0.37	1.72	+0.02	2.62	-0.05	1.64	-0.11		
4,500			2.42	+0.17	1.54	+0.21	1.38	-0.86	1.18	-0.09		
5,000							0.78	-1.12	0.46	-0.22		

[1] Naval air station.

TABLE 2.—*Free-air resultant winds (m. p. s.) during October, 1928*

Altitude m. s. l.	Broken Arrow, Okla. (233 meters) Mean Direction	Mean Velocity	Normal Direction	Normal Velocity	Due West, S. C. (217 meters) Mean Direction	Mean Velocity	Normal Direction	Normal Velocity	Ellendale, N. Dak. (444 meters) Mean Direction	Mean Velocity	Normal Direction	Normal Velocity
Meters	°		°		°		°		°		°	
Surface	S.	2.8	S. 2 W.	2.3	N. 85 E.	1.4	N. 47 E.	1.6	N. 55 W.	2.1	N. 68 W.	1.9
250	S. 4 E.	2.8	S. 2 W.	2.4	N. 84 E.	1.5	N. 45 E.	1.7				
500	S. 7 W.	4.0	S. 10 W.	3.6	S. 73 E.	2.2	N. 51 E.	2.1	N. 63 W.	2.2	N. 78 W.	2.0
750	S. 14 W.	4.5	S. 18 W.	4.3	S. 60 E.	2.0	N. 57 E.	1.7	N. 64 W.	3.5	N. 84 W.	2.9
1,000	S. 23 W.	4.7	S. 26 W.	4.3	S. 39 E.	1.0	N. 39 E.	0.8	N. 69 W.	4.3	N. 84 W.	3.7
1,250	S. 31 W.	4.5	S. 38 W.	4.6	S. 9 E.	1.1	N. 45 W.	0.6	N. 72 W.	5.5	N. 81 W.	4.5
1,500	S. 38 W.	4.4	S. 46 W.	4.7	S. 21 W.	1.1	N. 78 W.	1.4	N. 77 W.	6.7	N. 81 W.	5.4
2,000	S. 47 W.	4.6	S. 56 W.	5.1	S. 75 W.	4.0	N. 83 W.	2.5	N. 75 W.	8.0	N. 80 W.	6.9
2,500	S. 54 W.	4.0	S. 69 W.	5.5	S. 71 W.	6.5	N. 85 W.	4.5	N. 83 W.	7.5	N. 77 W.	8.3
3,000	S. 59 W.	3.8	S. 67 W.	6.4	S. 78 W.	8.8	N. 86 W.	5.5	N. 83 W.	8.9	N. 79 W.	9.5
3,500	S. 87 W.	3.9	S. 74 W.	7.4	S. 77 W.	10.3	S. 87 W.	6.6	N. 72 W.	8.1	N. 81 W.	11.0
4,000	N. 68 W.	2.7	S. 69 W.	8.1	S. 67 W.	9.6	S. 78 W.	6.3	S. 69 W.	13.0	N. 86 W.	12.0
4,500					S. 88 W.	12.2	N. 86 W.	6.3	N. 68 W.	16.0	S. 85 W.	13.5
5,000					N. 68 W.	12.0	N. 44 W.	7.6	N. 68 W.	16.0	N. 85 W.	14.7

Altitude m. s. l.	Groesbeck, Tex. (141 meters) Mean Direction	Mean Velocity	Normal Direction	Normal Velocity	Royal Center, Ind. (225 meters) Mean Direction	Mean Velocity	Normal Direction	Normal Velocity	Washington, D. C. (34 meters) Mean Direction	Mean Velocity	Normal Direction	Normal Velocity
Meters	°		°		°		°		°		°	
Surface	S. 2 E.	2.3	S. 45 E.	0.8	S. 55 W.	2.4	S. 51 W.	2.2	S. 84 W.	0.3	N. 53 W.	0.9
250	S. 1 E.	3.7	S. 31 E.	1.5	S. 52 W.	2.8	S. 50 W.	2.5	S. 82 W.	1.8	N. 53 W.	2.1
500	S. 15 W.	5.5	S. 15 E.	2.7	S. 52 W.	5.2	S. 57 W.	4.8	S. 82 W.	3.4	N. 62 W.	2.9
750	S. 14 W.	5.9	S. 7 E.	3.1	S. 59 W.	6.5	S. 65 W.	6.0	N. 64 W.	4.6	N. 65 W.	3.9
1,000	S. 22 W.	6.0	S. 4 W.	3.1	S. 63 W.	7.2	S. 71 W.	6.6	N. 67 W.	4.7	N. 61 W.	4.8
1,250	S. 21 W.	5.8	S. 13 W.	3.2	S. 68 W.	8.2	S. 75 W.	7.4				
1,500	S. 27 W.	5.6	S. 24 W.	3.2	S. 68 W.	9.4	S. 79 W.	8.1	N. 69 W.	6.4	N. 60 W.	6.3
2,000	S. 38 W.	5.3	S. 40 W.	3.3	S. 71 W.	10.1	S. 82 W.	9.3	N. 79 W.	7.4	N. 65 W.	6.9
2,500	S. 49 W.	4.9	S. 48 W.	3.6	S. 74 W.	10.9	S. 87 W.	10.2	N. 72 W.	7.7	N. 66 W.	7.8
3,000	S. 62 W.	4.9	S. 58 W.	3.9	S. 76 W.	10.8	S. 88 W.	11.0	N. 71 W.	9.0	N. 70 W.	8.3
3,500	S. 84 W.	5.6	S. 60 W.	4.1	S. 81 W.	12.1	N. 89 W.	12.6	N. 71 W.	10.4	N. 72 W.	9.3
4,000	N. 68 W.	12.1	S. 52 W.	4.1	S. 77 W.	11.8	S. 89 W.	13.9	N. 73 W.	11.9	N. 76 W.	9.9
4,500					S. 68 W.	13.2	S. 80 W.	16.1	N. 86 W.	13.0	N. 81 W.	9.6
5,000					N. 83 W.	11.4	N. 87 W.	16.0	N. 88 W.	15.3	N. 78 W.	10.2

WEATHER IN THE UNITED STATES

THE WEATHER ELEMENTS

By P. C. DAY

GENERAL CONDITIONS

The month was notable mainly for high barometric pressure over the East and Southeast, mild temperatures, particularly during the first half, and for the general absence of inclement weather over most sections.

PRESSURE AND WINDS

High pressure over the Atlantic coast districts effectively blocked the usual progress of storms moving eastward from the Mississippi Valley and most of these were forced first to the Lake region and thence eastward north of New England, with resulting lack of precipitation for long periods over many eastern districts.

The first few days were mainly free from important precipitation, but by the 4th cyclonic conditions had set in over the middle and upper Mississippi Valley and by the morning of the 5th considerable precipitation had occurred in that area and to the eastward as far as the Great Lakes and Ohio Valley. By the following morning pressure had increased materially, but light precipitation continued eastward to the Atlantic coast and southward to the Florida peninsula, though in diminishing amounts. With the exception of light precipitation over the Lake region and to the eastward, no other important precipitation occurred in any part of the country during the first decade.

By the morning of the 11th pressure was again falling over the Great Plains and to the southwestward, and some snow or rain was falling over the northern mountain districts and in the western Canadian Provinces. This pressure distribution brought precipitation by the morning of the 12th, generally light, however, over an extensive area from central Arizona, New Mexico, and western Texas northeastward to the upper Lakes and continued locally westward over portions of the Rocky Mountain region. High pressure over the Southeastern States barred the progress of the low pressure into that region and precipitation therefrom continued locally in the mountains of the west and in the Lake region and northern New England. Following this low pressure again formed over the Southwest and moved to the Mississippi Valley by the morning of the 15th, and by the following morning the most widely extended rain area of the month had covered nearly all parts of the country from the Mississippi Valley to the Appalachian Mountains and to the South Atlantic coast. The rainy conditions remained fairly stationary during the following two days and finally passed northeastward into Canada by the 19th. This was the most extensive storm of the month and brought the greatest part of the precipitation over large areas.

By the morning of the 21st low pressure had again developed over the southern plains and in its passage thence to the Great Lakes by the 24th considerable rain occurred from the Mississippi Valley eastward to the Atlantic coast, the falls being fairly heavy in portions of the Gulf States and locally in the Ohio and middle Mississippi Valleys and Atlantic Coast States.

Considerable precipitation occurred from the Ohio Valley northeast to New England on the 27th and 28th and over the southern Great Plains on the 29th and 30th, the rain area extending on the 31st westward into the southern mountain and plateau regions.

The far Western States had mainly little precipitation save over the coast districts from central California northward about the 3d to 5th, continuing over the more northern district for several days, but mostly light, and over the same districts from about the middle to the end of the second decade. The last decade had little precipitation in the far West until near the end, and during the same period much clear weather prevailed over other portions of the West, and in fact throughout the country as a whole.

Anticyclones were somewhat dominant, but as they were most pronounced in the lower latitudes they exerted no great influence in lowering the temperatures, except about the 11th and 12th when a rather strong area of high pressure, moving from the Canadian Provinces extended into the Missouri Valley and eastward along the northern border, brought a sharp lowering of the temperature over most northern districts.

The latter half of the month had more frequent incursions of high areas from the Canadian Provinces, and while temperatures were not decidedly low yet the weather was distinctly cooler than had prevailed earlier in the month.

Compared with the normal the mean sea-level pressure was above in nearly all parts of the country, and it was distinctly higher than normal over most eastern and southeastern districts. The pressure was also almost universally higher than prevailed during the preceding month, and this condition existed in Canada as well.

The presence of anticyclonic conditions favored an unusually stable condition of the atmosphere and storms were infrequent as is often the case in mid-autumn. No loss of life was reported and only limited damage to property resulted from high wind or other manifestations of atmospheric stress.

The distribution of the average atmospheric pressure and the prevailing direction of the wind are shown on Chart VI, and the departure of the mean pressure from the normal and the changes in pressure from the preceding month appear as insets to Charts II and III.

TEMPERATURE

Except in the Plateau States, where both months were warmer than normal, the October departures of temperature were almost always the reverse of the September departures. Especially from the Plains States eastward October was mild, while September there had been cooler than normal.

The opening decade of October was considerably warmer than normal in nearly all districts, particularly between the Mississippi River and Rocky Mountains. During the week following the weather continued warm in far more than half of the country, with unusual warmth for the season in the central valleys, where temperatures averaged mainly from 10° to 15° warmer than normal. This week was cool, however, in the far West and in those central districts near the Canadian border.

The week from the 16th to 23d was particularly warm in the Northeast, and was mainly warmer than normal elsewhere, save in the Plains States and the near Southwest and on the immediate Pacific coast. The last eight days of the month were cooler than normal east of the Mississippi River, also in the northern and middle portions west of the river to the Continental Divide, and again in most of California; this period was quite warm, however, in the plateau region and the Rio Grande Valley.

October as a whole was warm except in the upper Missouri Valley and the northern Rocky Mountain States

and along the Pacific coast. The excess was large, usually 4° to 6° per day, from the southern lake region southward, to the Gulf and southwestward to the Rio Grande, also in the southern Appalachian districts.

In Oklahoma the month was the warmest October of the nearly 40 for which means from well-distributed stations have been computed, and from Mississippi to New Mexico it was among the warmest Octobers.

The highest temperatures usually occurred about the 9th to 14th from the Dakotas and Nebraska eastward to the Middle and North Atlantic States, the marks reached on the 10th to 12th from the middle Missouri Valley to the lower Lake region being at many points the highest October temperatures of record. In the western Cotton States the 1st was usually the warmest day and in the eastern either the 6th or the 7th. The highest marks in the far West were noted about the 6th to 8th. The highest temperature recorded was 110° in interior southern California, on the 7th.

The lowest temperatures occurred usually during the final week, save just before the middle of the month in California and many Plateau and Rocky Mountain States and during the first half of the final decade in the majority of the Plains and Gulf States. The lowest temperature reported was 3° below zero, in central Montana, on the 29th. Temperatures below freezing were recorded in some portions of all States save a few Southeastern and Middle Gulf States.

PRECIPITATION

Save in a portion of the extreme Northwest and from Oklahoma and Arkansas northeastward to the southern part of the Lake region, the early and late portions of the month brought little rain, yet the time distribution of the rain, coming mainly about the middle of the month, was not unfavorable, on the whole. The geographic distribution was notably favorable. The Atlantic States, where September had been so wet, received less rain than normal; from Virginia to southern New England the shortage was especially marked. Louisiana and Texas, which had excesses during September, had moderate deficiencies in October.

From California and Oregon northeastward to Montana and North Dakota a shortage of precipitation in October followed a deficiency in September. In California the October precipitation averaged less than one-third of the normal.

Between the Appalachians and the Rockies, also in the southern plateau, there was more than normal precipitation nearly everywhere, save near the Gulf and along the Canadian boundary. The excess was considerable from Wisconsin, Iowa, and Nebraska southeastward to Tennessee and Arkansas, save that the Ozark region in Missouri had a deficiency.

SNOWFALL

The October snowfall covered less of the country than usual and especially it was scanty as a rule, in the more northern States from Minnesota and Iowa eastward.

About the 10th to 13th considerable snow fell from southwestern and south-central Montana and southeastern Idaho south eastward over Wyoming and parts of the States adjoining. At Lander, Wyo., the fall at this time was 22 inches and the ground remained covered for more than 10 days. At the very end of the month a noteworthy fall of snow occurred in Nebraska and southern South Dakota, with most of Wyoming and parts of Colorado and Kansas.

The elevated portions of the middle Mountain and Plateau States seem to have had somewhat more snow than the average October amounts indicated by past seasons.

RELATIVE HUMIDITY

The percentage of relative humidity was usually above normal in the central and southeastern portions, particularly in the lower Ohio Valley and most parts of the Carolinas. In the Northeast, in western Texas and southern New Mexico, in most parts of the plains, and especially in the northernmost districts from western Minnesota to the Cascade Mountains the humidity was less than normal. In Colorado and thence southwestward to the southern California coast and likewise on the immediate north Pacific coast the relative humidity averaged somewhat greater than normal.

SEVERE LOCAL STORMS OCTOBER, 1928

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the annual report of the chief of bureau]

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Pawnee County, Okla	4	4 p. m.	1,760		$60,000	Heavy hail	Poultry killed; crops ruined; roofs, automobiles, windows, and other property damaged; path 25 miles long.	Official, U. S. Weather Bureau.
Coffey County, Kans	4	4-5 p. m.	5 [1]		6,000	do	Chief damage at Le Roy where much damage to property resulted. Path 20 miles.	Do.
Mahaska County, Iowa	4	6:15 p. m.				Tornado	Damage to small buildings and trees reported	Do.
Keokuk County, Iowa	4	6:30 p. m.				do	Considerable damage to small buildings	Do.
Poweshiek County, Iowa	4	do				do	do	Do.
Iowa County, Iowa	4	7:10 p. m.			2,000	Wind	Character of damage not reported	Do.
Cedar County, Iowa	4	8 p. m.	440		4,000	Tornado	Character of damage not reported. Path 1 mile	Do.
Marion County, Iowa	4	do			5,000	Wind	Character of damage not reported	Do.
Carlinville, Ill. (near)	4	8:30 p. m.	100-200		7,000	Tornado	Outbuildings blown down; roofs torn off; orchard trees uprooted; 1 person injured; path 5 miles.	Do.
Taylorville, Ill. (7 miles east of).	4	9:30 p. m.	440			do	A few small farm buildings damaged or wrecked; grove badly damaged; path 1 mile.	Do.
Oconto County (central) to Marinette County (northeastern), Wis.	4	10:30 p. m.	60-880		24,000	Severe squalls	Damage chiefly to farm property other than crops.	Do.
Clinton County, Iowa	4				3,000	Wind	Small buildings and trees damaged	Do.
Morrison, Ill	4				3,000	Severe electrical	Light service impaired, farmhouse and shed burned.	Do.
Tallula, Ill. (near)	4				3,400	do	2 barns struck, 1 a total loss; other minor damage	Do.
Antelope County, Nebr. (southeastern).	10	4 p. m.				Hail and wind	Some crops injured; roofs damaged; windows broken.	Do.
Petersburg, Nebr	11	3:30 p. m.	3,520			Hail	Corn flattened; poultry killed; windows borken; path 15 miles.	Do.
Finney, Scott, and Lane Counties, Kans.	11	P. m.	10		20,000	Tornado	Many farm buildings destroyed	Do.
Posey County (eastern) to Vanderburg County (western), Ind.	16	1 p. m.	20			do	Many houses unroofed, some wrecked; scores of outbuildings demolished; trees and poles blown down; stock killed; path 12 miles.	Do.
Monmouth, Ill. (near)	17					Severe whirling dust storm.	Several small buildings moved from foundations; path several miles.	Do.

[1] Miles.

RIVERS AND FLOODS

By R. E. SPENCER

No floods of importance occurred during October, 1928. In the Atlantic drainage, the high stages were mainly continuations of the August-September floods previously reported upon, and were attended by no additional damage.

Because of frequent previous floods this summer along the Grand River of Missouri, no crops remained to be damaged by the rise of October 18–20 in that stream; and it had no other consequence except some slight inconvenience to transportation.

[All dates in October except as otherwise specified]

River and station	Flood stage	Above flood stages—dates: From—	Above flood stages—dates: To—	Crest: Stage	Crest: Date
ATLANTIC DRAINAGE					
	Feet			Feet	
Connecticut: Bellows Falls, Vt	12	[1]	18	13.0	2 and 10.
		21	24	12.8	22.
		29	[2]	12.8	31.
Tar: Greenville, N. C	14	[1]	[3]		
Waccanaw: Conway, S. C	7	[3]	11	13.4	Sept. 30.
Peedee: Mars Bluff, S. C	17	[3]	6	29.6	Sept. 23.
Santee:					
Rimini, S. C	12	[1]	13	30.4	Aug. 21.
Ferguson, S. C	12	[1]	15	20.6	Aug. 22.
Saluda: Three Miles Post (near Columbia), S. C	8	5	6	12.1	5.
		18	20	10.75	19.
Altamaha: Everett City, Ga	10	[1]	1	15.0	Aug. 27–28.
MISSISSIPPI DRAINAGE					
Tippecanoe: Norway, Ind	6	29	29	6.0	29.
Elk: Fayetteville, Tenn	14	18	18	20.4	18.
Grand:					
Gallatin, Mo	20	18	19	25.4	18.
Chillicothe, Mo	18	18	20	23.7	19.

[1] Continued from last month.
[2] Continued at end of month.
[3] Below flood stage at 8 a. m., Oct. 1, 1928.

MEAN LAKE LEVELS DURING OCTOBER, 1928

By UNITED STATES LAKE SURVEY

[Detroit, Mich., November 5, 1928]

The following data are reported in the "Notice to Mariners" of the above date:

Data	Lakes [1]: Superior	Michigan and Huron	Erie	Ontario
Mean level during October, 1928:	Feet	Feet	Feet	Feet
Above mean sea level at New York	603.55	580.45	571.86	245.76
Above or below—				
Mean stage of September, 1928	+0.15	+0.03	−0.26	−0.41
Mean stage of October, 1927	+0.91	+1.33	+0.52	+0.77
Average stage for October, last 10 years	+1.37	+0.83	+0.16	+0.49
Highest recorded October stage	−0.09	−2.59	−1.84	−2.05
Lowest recorded October stage	+2.16	+2.54	+1.26	+2.09
Average departure (since 1860) of the October level from the September level	−0.05	−0.23	−0.31	−0.34

[1] Lake St. Clair's level: In October, 1928, 575.02 feet.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS, OCTOBER, 1928

By J. B. KINCER

General summary.—During the first decade, except where plowing and fall seeding were retarded by dry soil, the weather was mostly favorable for seasonal farm operations and good progress was reported quite generally. The prevailing warmth and much sunshine were especially helpful in drying out the corn crop, for harvesting operations, picking cotton, and for fall plowing and seeding wherever the soil moisture was sufficient. There were no damaging frosts, but additional reports of harm to some late crops—mostly minor—by frosts of the preceding month were received from some of the Northern States.

The second decade was warm over the eastern half of the country and, although the prevailing weather had some unfavorable aspects, conditions were generally favorable. Little or no harm was reported from low temperatures, although freezing weather extended south to extreme northwestern Oklahoma and northern New Mexico, with light frost in parts of northern Texas. The geographic distribution of rainfall was mostly favorable; in the upper Mississippi Valley, the Lake region, and the Northeast, showers delayed field work, but were otherwise helpful, while in the central valley States further rains were very beneficial with the drought largely relieved.

During the last decade rain hindered outdoor operations to some extent in the Lake region and the Northeast; otherwise field work made good advance until near the close of the month, when widespread rains in the Southwest stopped outside operations. The first general freezing weather of the season overspread the Eastern States as far south as southern Virginia and in the West to portions of Oklahoma, but little damage resulted.

Small grains.—During the first decade moderate to generous showers in the central and eastern portions of the Winter Wheat Belt were very beneficial in conditioning the soil for seeding and for germination of the grain already sown, but in western parts more moisture was needed, with seeding suspended in western Kansas and delayed in Oklahoma. Conditions continued favorable in Atlantic coast sections and the outlook was improved by generous rains in the Pacific Northwest.

During the second decade the dry conditions were generally relieved, but over the western half of the belt it was still unfavorably dry in some districts. Missouri, Iowa, Kansas, and Nebraska were well supplied with soil moisture as a result of the rains, but in parts of the Southwest it continued dry. Unfavorable drought continued in the Pacific Northwest, but in the Atlantic Coast States conditions were generally satisfactory.

During the last decade rains in the southwestern Wheat Belt were of much benefit, especially in breaking the drought in western Oklahoma and northern Texas. The main producing area had sufficient moisture rather generally, with this relief, and the crop was making favorable advance. The Pacific Northwest continued droughty, but in the Atlantic area satisfactory conditions prevailed.

Corn.—During the first decade the warm, dry, sunny weather over the main producing sections made generally excellent conditions for drying out the corn crop. Rapid drying was reported in the Ohio Valley and in Iowa, with cribbing begun in many counties of the latter and hogging active. The crop was all made and being cribbed in Missouri, while in the Great Plains it was drying rapidly, with cribbing begun in Kansas.

During the second decade corn dried out rapidly in the eastern Ohio Valley and husking advanced well, but in the western part there was some delay by wet weather. In Iowa heavy rains interrupted husking; some corn was fit to crib, but mostly for immediate use only; high winds caused much down corn with husking difficult and many ears molding or sprouting. In the Great Plains and Missouri harvesting made good advance.

Corn husking made rapid progress in the Ohio Valley during the last decade and considerable shredding was accomplished. In Iowa husking varied from scarcely begun to half done; the feeding value and general quality of the crop were reported the best for several years, but it was mostly too wet for cribbing in the extreme eastern and southern portions. Husking advanced in the Great Plains, with cribbing beginning in Kansas and being general in Missouri.

Cotton.—During the first decade in the Atlantic States the warmth and sunshine were favorable and cotton opened rapidly, with picking and ginning advancing well. In the central States of the belt conditions favored rapid opening and also harvesting, except for considerable rain in places, principally in Arkansas. In Oklahoma warmth and persistent dryness made a continuation of unfavorable conditions in the west, but the bulk was open and being picked rapidly. In Texas progress was poor in the northwest, with premature opening, but the crop was mostly made elsewhere, with top-crop conditions poor; the weather favored picking.

During the second decade frequent rains caused considerable delay to cotton picking east of the Mississippi River, except in Atlantic coast areas where generally good advance was reported. There was also some interruption in Louisiana, but very good advance was reported from Arkansas. In Oklahoma cotton was mostly open and picking advanced rapidly, while in Texas the crop was mostly out in southern and central portions and fair to good progress was reported from the Northwest.

During the last decade fair weather favored picking and ginning over the eastern belt, but toward the close of the month rains interrupted this work in the northwestern, but gathering was well along in all sections. Some cotton in northwestern Texas was blown out by high winds and local harm to staple was reported in the central-northern portions of the belt.

Miscellaneous crops.—Pastures were fair to good east of the Appalachian Mountains, but to the westward there was a rather general need of moisture most of the month. Rains were of some benefit in parts of the upper Mississippi Valley, while showers were helpful in the central Rocky Mountain region and the Southwest. It continued generally unfavorably dry in the Great Basin and rather generally in Pacific coast sections. Livestock held up well, however, although large numbers were on feed in the Great Basin.

Potato digging progressed during the month and was practically completed at the close. Truck crops made mostly satisfactory advance, although killing frosts damaged some late truck in Middle Atlantic States during the latter part. Sugar-cane conditions continued excellent in Louisiana and sugar-beet digging progressed well. Cool weather at the close improved citrus in Florida and hastened coloring; citrus did well in California.

WEATHER OF THE ATLANTIC AND PACIFIC OCEANS

NORTH ATLANTIC OCEAN

By F. A. YOUNG

The weather conditions were exceptionally severe over the middle and eastern sections of the North Atlantic. West of the fiftieth meridian the number of days with gales was somewhat below the normal and along the American coast moderate conditions prevailed with the exception of a few disturbances that will be referred to later.

Charts VIII to XII show the conditions from the 11th to 15th, inclusive, during the flight of the German airship *Graf Zeppelin*, which left Germany on the 11th for the United States.

The number of days with fog, judging from reports received, was considerably below the normal over the Grand Banks, the greater part of the steamer lanes and off the European coast, while not far from normal along the American coast between Hatteras and Newfoundland.

On the 1st a disturbance was central near 41° N., 51° W., that moved rapidly eastward, reaching its greatest extent and intensity on the 3d when near 52° N., 30° W. On that date the storm area extended over the northern steamer lanes from the fifteenth to the fortieth meridians and vessels in the southwesterly quadrants reported northwesterly gales of force 11 and 12 at the time of observation. By the 4th this disturbance had diminished somewhat in force, although whole westerly gales still prevailed over a considerable area; by the 5th it was off the west coast of Ireland, with moderate conditions near the center, although southerly gales were reported from the vicinity of the Azores. On the 5th there was a second LOW central near 45° N., 45° W., that also became dangerous as it traveled eastward, and from the 6th until the 11th a succession of severe gales prevailed over portions of the middle and eastern sections of the steamer lanes.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, 8 a. m. (seventy-fifth meridian), North Atlantic Ocean, October, 1928*

Stations	Average pressure	Departure [1]	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Julianehaab, Greenland	29.61	([2])	30.08	29th	29.10	16th.
Belle Isle, Newfoundland	29.77	−0.10	30.20	28th	29.16	15th.
Halifax, Nova Scotia	30.07	+0.07	30.58	31st	29.48	25th.
Nantucket	30.12	+0.10	30.54	31st	29.52	24th.
Hatteras	30.16	+0.13	30.44	30th	29.74	24th.
Key West	30.00	+0.02	30.14	26th [3]	29.92	1st.[3]
New Orleans	30.08	+0.07	30.30	26th	29.90	1st.[3]
Cape Gracias, Nicaragua	29.86	−0.04	29.90	20th [3]	29.78	24th.
Turks Island	30.02	+0.07	30.08	26th [3]	29.96	4th.[3]
Bermuda	[4] 30.18	+0.16	30.36	28th	29.88	1st.
Horta, Azores	30.28	+0.16	30.56	25th	29.92	3d.
Lerwick, Shetland Islands	29.63	−0.16	30.20	3d [3]	28.46	20th.
Valencia, Ireland	29.74	−0.17	30.29	1st	29.11	26th.
London	29.85	−0.06	30.30	3d	29.28	27th.

[1] From normals shown on Hydrographic Office Pilot Chart, based on observations at Greenwich mean noon or 7 a. m. seventy-fifth meridian.
[2] No normal available.
[3] And on other dates.
[4] Average of 27 observations.

On the 10th a disturbance of tropical origin was somewhere in the vicinity of 22° N., 37° W., as indicated by the storm report from the Dutch S. S. *Prins Frederik Hendrik*. Unfortunately, this is an unfrequented part of the ocean and so few reports have been received that it has been difficult to trace its track accurately until the 14th, the position on that date being shown on Chart XI. It was on the 14th that the American tanker *David C. Reid* foundered, her approximate position being given in an SOS as 37° N., 38° W., apparently not far from the center of the disturbance just referred to.

From the 17th to 21st the middle and eastern sections of the steamer lanes were again swept by a succession of gales that reached their greatest intensity on the 19th. On the 21st a LOW was central off the south coast of Newfoundland that moved eastward, increasing in inten-

sity, and on the 23d and 24th gales of hurricane force were once more encountered over the steamer lanes east of the forty-fifth meridian.

On the 24th Eastport, Me., was near the center of a LOW that proved to be considerably less severe than its predecessors, although on the evening of this day moderate gales were reported from the vicinity of Hatteras.

On the 25th stormy conditions prevailed over the greater part of the steamer lanes and on the 26th and 27th northerly and northwesterly gales prevailed between the twentieth meridian and the European coast.

From the 24th to the 26th moderate to strong gales were reported from the region between the Bermudas and Nantucket.

At different periods between the 27th and the end of the month heavy weather occurred over the middle and eastern sections of the steamer lanes, although on the 28th moderate conditions were the rule over the ocean as a whole.

On the 30th there was a disturbance of limited extent and duration in the Caribbean Sea, as shown by storm report from the British S. S. *Ulua*.

OCEAN GALES AND STORMS, OCTOBER, 1928

Vessel	Voyage		Position at time of lowest barometer		Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Highest force of wind and direction	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH ATLANTIC OCEAN			° ′	° ′				Inches					
Waaldijk, Du S. S.	Norolk	English Channel.	41 37 N.	51 00 W.	Sept. 30.	2 p., Oct. 1.	Oct. 2.	29.42	SE.	SW., 8.	NNW.	SW., 9.	SW.-WNW.
Thuringia, Ger. S. S.	Cobh	Halifax	48 10 N.	35 00 W.	Oct. 2.	10 a., 2.	4.	28.82	SSE.	SSW., 11.	W.	WNW., 12	
Chief Skidegate, Br. S. S.	Canal Zone	Rotterdam	43 20 N.	42 30 W.	2.	4 p., 2.	4.	29.49	S.	W., 7.	W.	WNW., 12	SW.-W.-NW.
American Farmer, Am. S. S.	London	New York	49 33 N.	33 56 W.	2.	4 p., 2.	4.	28.35	NW.	W., 6.	W.	NW., 12.	SE.-W.-NW.
Dresden, Ger. S. S.	New York	Cobh	48 39 N.	30 25 W.	1.	10 a., 3.	4.	28.81	SE.	WSW., 10.	SW.	NW., 12.	
Western Ally, Am. S. S.	Rotterdam	New York	51 02 N.	27 35 W.	2.	5 p., 3.	5.	28.46	ESE.	S., 10.	W.	SSE., 11.	SSE.-S.
München, Ger. S. S.	Cobh	do.	44 21 N.	55 36 W.	4.	8 p., 4.	5.	29.64	W.	NW., 10.	N.	NW., 10.	W.-NNW.
Rochambeau, Fr. S. S.	Havre	do.	45 00 N.	45 20 W.	5.	3 p., 5.	6.	29.29	SE.	W.	WNW.	NW., 12.	
Sahale, Am. S. S.	Bremen	Galveston	39 49 N.	31 12 W.	5.	7 a., 5.	5.	29.82	S.	SSW.		WSW., 10.	S.-SW.
Lorain, Am. S. S.	do.	Portland, Me.	49 30 N.	41 25 W.	6.	8 a., 6.	7.	29.03	NNW.	NNW., 11.	WNW.	—, 11.	Steady.
Dannedaike, Am. S. S.	Hamburg	New York	46 20 N.	33 15 W.	6.	4 a., 6.	7.	29.11	SW.	SW., 11.	W.	SW., 11.	SSW.-W.
Waaldijk, Du. S. S.	Norfolk	English Channel.	49 33 N.	14 46 W.	6.	2 p., 8.	9.	29.28	SSW.	SSW., 8.	W.	W., 10.	SW.-W.
Republic, Am. S. S.	New York	Cobh	50 05 N.	33 25 W.	7.	8 p., 9.	11.	29.04	SSW.	SW., 9.	W.	W., 10.	Steady.
Prins Frederik Hendrik, Du. S. S.	Amsterdam	Surinam	20 41 N.	37 34 W.	10.	8 p., 10.	11.	29.96	E.	E., 10.	SSE.	E., 10.	E.-SE.-SSE.
Berlin, Ger. S. S.	Bremerhaven	New York	49 08 N.	27 17 W.	10.	4 p., 10.	11.	29.10	WSW.	WSW.	W.	W., 11.	WSW.-W.
Myriam, Fr. S. S.	St. Nazaire	Curacao	29 50 N.	47 22 W.	13.	4 p., 13.	14.	29.64	NE.	N., 8.	NW.	NNE., 8.	
Sinsinawa, Am. S. S.	Casablanca	New York	37 02 N.	64 00 W.	13.	10 p., 13.	14.	29.91	W.	W., 8.	NW.	W., 9.	W.-NW.
Wray Castle, Br. S. S.	Oran	do.	34 41 N.	41 45 W.	14.	11 a., 14.	15.	29.01	SE.	SSE.	SW.	SSE., 12.	SE.-S.-WSW.
Exporter, Am. S. S.	Gibraltar	do.	35 25 N.	41 05 W.	14.	10 a., 14.	14.	28.95	W.	SW., 12.	W.	SW., 12.	SW.-W.-SW.
Delilian, Br. S. S.	Liverpool	Kingston	37 55 N.	39 08 W.	14.	2 p., 14.	14.	29.07	SSE.	SSE., 12.	WSW.	SSE., 12.	SSE.-WSW.
Duivendrecht, Du. M. S.	Texas City	Thameshaven	48 51 N.	26 01 W.	15.	8 a., 15.	15.	29.28	S.	SSW., 9.	SW.	S., 10.	SSW.-SW.
Westward Ho, Am. S. S.	Galveston	Liverpool	44 45 N.	42 55 W.	17.	2 a., 17.	21.	29.69	W.	N., 7.	WNW.	NW., 10.	
Wellfield, Br. M. S.	Tyne	Galveston	58 19 N.	8 02 W.	18.	Noon, 18.	19.	28.48	SSW.	SSW., 9.	NW.	NW., 10.	Steady.
West Eldara, Am. S. S.	New York	Antwerp	49 30 N.	18 40 W.	19.	9 a., 19.	19.	28.65	S.	WSW.	WNW.	W., 11.	
West Carnifax, Am. S. S.	Gibraltar	Boston	38 18 N.	63 30 W.	20.	1 p., 20.	21.	29.80	SSW.	SSW., 9.	WNW.	SSW., 9.	SSW.-SW.
Ruth, Nor. S. S.	Archangel	West Hartlepool.	59 19 N.	5 18 E.	19.	8 a., 20.	21.	29.11	SE.	SE.	SSW.	SE., 10.	SE.-S.
Mississippi, Br. M. S.	Halifax	London	45 44 N.	56 50 W.	20.	3 a., 21.	23.	29.45	SW.	SW., 9.	NW.	SW., 9.	SW.-WNW.
Bussum, Du. S. S.	Leith	Montreal	56 46 N.	40 28 W.	22.	1 p., 22.	23.	28.69	NE.	N., 9.	N.	N., 10.	E.-NE.-N.
Bellepline, Am. S. S.	Rotterdam	New York	48 25 N.	39 20 W.	21.	11 p., 22.	23.	29.54	WSW.	W., 12.	NW.	—, 12.	WSW.-WNW.
Stuttgart, Ger. S. S.	New York	Southampton	47 48 N.	31 19 W.	23.	10 a., 23.	23.	29.91	NW.	NW., 9.	NW.	NW., 10.	Steady.
Karlsruhe, Ger. S. S.	Bremerhaven	New York	48 55 N.	25 04 W.	20.	4 a., 23.	25.	29.42	WSW.	WSW., 10.	SW.	WSW., 11.	
Columbus, Ger. S. S.	Plymouth	do.	49 46 N.	49 13 W.	23.	4 p., 23.	25.	28.98	SW.	W., 11.	SW.	W., 11.	
El Almirante, Am. S. S.	New Orleans	do.	30 50 N.	79 15 W.	24.	9 a., 24.	24.	29.76	NW.	NW., 8.	N.	NW., 8.	NW.-N.
Balsam, Am. S. S.	Cardiff	Baltimore	38 30 N.	64 15 W.	24.	3 p., 24.	26.	29.43	SSE.	SSW.	NNW.	SSW., 9.	SSE.-SW.
Darian, Br. S. S.	Liverpool	Charleston	51 39 N.	7 24 W.	24.	Noon, 24.	27.	29.08	SW.	SW.	NW.	SW., 10.	SW.-WNW.
Emile, L. D., Fr. S. S.	Rotterdam	Montreal	50 21 N.	1 19 W.	26.	4 a., 27.	27.	28.90	SW.	SE., 9.	NE.	—, 9.	SSW.-SE.-NE.
Nubian, Br. S. S.	Montreal	Avonmouth	53 40 N.	26 54 W.	29.	7 a., 29.	31.	29.76	SW.	W., 10.	N.	W., 10.	
Ulua, Br. S. S.	Canal Zone	New York	20 42 N.	84 21 W.	30.	5 p., 30.	30.	29.85	ENE.	ENE., 7.	ENE.	E., 9.	
Tulsa, Am. S. S.	Glasgow	Charleston	48 10 N.	13 00 W.	30.	2 a., 30.	30.	29.78	NW.	NW., 8.	NW.	NW., 12.	S.-W.
Beemsterdijk, Du. S. S.	Rotterdam	Quebec	53 44 N.	36 55 W.	31.	10 a., 31.	Nov. 1.	29.75	S.	WSW., 6.	SW.	NNW., 10.	S.-WSW.
NORTH PACIFIC OCEAN													
Egypt Maru, Jap. S. S.	Miike	Vancouver	49 47 N.	131 27 W.	5.	5 p., 5.	6.	29.19		S., 9.		S., 9.	SSE.-S.
Illinois, Am. S. S.	Hong Kong	San Francisco	47 03 N.	175 42 W.	5.	5 p., 5.	7.	29.50	SW.	W., 8.	NW.	NW., 9.	SW.-W.
Golden Sun, Am. S. S.	do.	do.	38 40 N.	149 30 E.	6.	5 p., 6.	6.	29.74	ESE.	S., 8.	NE.	NNE., 11.	SE.-S.
Santa Veronica, Am. S. S.	Baltimore	Hilo	15 25 N.	110 45 W.	7.	5 p., 7.	8.	29.76	S.	S., 10.	SSW.	SSW., 10.	SW.-S.
Astral, Am. S. S.	San Pedro	Hong Kong	35 50 N.	169 51 W.	8.	7 p., 8.	9.	29.39	SW.	W., 10.	W.	W., 11.	WSW.-W.
Chokoh Maru, Jap. S. S.	Miike	Vancouver	48 37 N.	171 28 W.	9.	Mdt., 9.	9.	29.04	NE.	N., 8.	N.	NE., 9.	
Illinois, Am. S. S.	Hong Kong	San Francisco	45 43 N.	157 50 W.	9.	10 a., 9.	9.	29.52	E.	SE., 10.	S.	SE., 10.	E.-SE.
Columbia Maru, Jap. M. S.	Tacoma	Yokohama	41 15 N.	147 51 E.	8.	6 a., 9.	9.	29.43	ESE.	S., 10.	SE.	S., 10.	SE.-S.-SW.
Haisho Maru, Jap. S. S.	Muroran	Vancouver	49 44 N.	162 00 W.	8.	Mdt., 8.	10.	29.39	E.	E., 10.	S.	E., 10.	E.-S.
Erviken, Nor. S. S.	Yokohama	Juan de Fuca.	48 20 N.	172 00 W.	8.	10 p., 10.	10.		E.	E., 8.	E.	NE., 12.	NE.-SE.
Korea Maru, Jap. S. S.	San Francisco	Honolulu	37 00 N.	124 10 W.	10.	4 p., 10.	11.	29.77	WNW.	NNW., 7.	N.	NNW., 9.	NNW.-N.
Lowther Castle, Br. S. S.	Panama	do.	16 34 N.	113 29 W.	15.	2 a., 16.	16.	29.48	SW.	ENE., 7.	NW.	SSW., 8.	ESE.-ENE.
Golden Sun, Am. S. S.	Hong Kong	San Francisco	47 20 N.	165 15 W.	15.	4 p., 15.	17.	29.19	S.	SSW., 9.	WNW.	W., 10.	S.-SW.
Kohnan Maru, Jap. S. S.	Miike	Coos Bay	49 55 N.	162 28 W.	15.	3 a., 16.	17.	28.72	N.	W., 11.	WSW.	—, 12.	
Arabia Maru, Jap. S. S.	Victoria	Yokohama	52 07 N.	165 57 W.	15.	6 a., 16.	17.	28.48	SE.	N., 9.	WNW.	NNW., 11.	SE.-N.
Iwatesan Maru, Jap. S. S.	Yokohama	Seattle	50 35 N.	156 00 W.	15.	1 p., 16.	17.	28.94	SSE.	SW., —.	SW.	S., 9.	
Astral, Am. S. S.	San Pedro	Hong Kong	33 37 N.	149 25 E.	17.	1 a., 19.	19.	29.66	S.	S., 9.	SW.	SSW., 10.	S.-SSW.
Mayebashi Maru, Jap. S. S.	Yokohama	San Francisco	47 05 N.	179 55 E.	18.	Noon, 20.	21.	29.68	SSW.	SW., 8.	W.	W., 9.	SW.-WNW.
Olympia Maru, Jap. M. S.	do.	Seattle	43 20 N.	156 58 E.	19.	4 p., 19.	20.	29.13	ENE.	SSW., 5.	WNW.	NNW., 9.	ENE.-SSW.
Kinkasan Maru, Jap. S. S.	Miike	Long View	49 18 N.	170 14 W.	19.	6 p., 19.	20.	28.74	SSW.	W., 9.	W.	SSW., 10.	SSW.-W.-NW.
Kohnan Maru, Jap. S. S.	do.	Coos Bay	48 11 N.	142 04 W.	20.	5 p., 20.	21.	29.56	S.	S., 11.	SSW.	S., 11.	S.-SSW.
Olympia Maru, Jap. M. S.	Yokohama	Seattle	50 00 N.	174 37 W.	23.	Noon, 23.	25.	28.84	SSW.	WSW., 8.	WSW.	W., 9.	
Yuri Maru, Jap. S. S.	Muroran	Vancouver	46 42 N.	167 58 E.	23.	11 a., 23.	25.	29.08	S.	S., 8.	WNW.	WNW., 10	S.-SSW.
Tokiwa Maru, Jap. S. S.	Yokohama	Victoria	48 12 N.	171 25 W.	27.	8 a., 28.	28.	28.86	SE.	SSE., 8.	SSW.	S., 10.	SE.-SSE.-S.
Shelton, Am. S. S.	Otaru	San Francisco	49 00 N.	178 45 W.	28.	2 a., 29.	29.	28.75	NE.	NW., 8.	WNW.	—, 10.	NW.-WNW.
Yuri Maru, Jap. S. S.	Muroran	Vancouver	49 44 N.	147 00 W.	28.	6 p., 31.	31.	28.09	SE.	E., 1.	SSE.	E., 9.	ENE.-E.-S.
Tacoma, Br. S. S.	Hankow	San Francisco	40 00 N.	154 45 W.	31.	9 p., 31.	Nov. 2.	28 27	SSW.	W., 11.	SSW.	SSW., 11.	W.-NW.-SW.
SOUTH PACIFIC OCEAN													
Weirbank, Br. S. S.	Makatea Is.	Fremantle	37 45 S.	137 30 E.	3.	9 p., 7.	8.	29.05	SW.	W., 9.	W.	SW. 10.,	Steady.

NORTH PACIFIC OCEAN

By WILLIS E. HURD

Early in October the Aleutian cyclone took on a real winter phase of development, covering the Gulf of Alaska and extending far southward along the coast, giving lowest pressures for the month at coast stations from Juneau to Tatoosh Island. It was followed over Alaska by a strong anticyclone, upon the passage of which cyclonic conditions became reestablished, dominating the weather thenceforth to the end of October over much of the northeastern part of the ocean. From the 20th to the 24th the cyclone intensified greatly, the barometer falling to 28.18 at Kodiak on the 20th. On the 31st the center of the disturbance lay south of the Gulf of Alaska, probably near 50° N., 147° W, where the lowest reported pressure reading of the month, 28.09 inches, occurred.

Consequent upon the far-reaching incursions of the cyclone, the Pacific-California anticyclone underwent a period of considerable instability, fluctuating back and forth, and frequently dividing and diminishing in area.

Pressure data for several island and coast stations in west longitudes are contained in the following table:

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level at indicated hours, North Pacific Ocean, October, 1928*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Dutch Harbor [1]	29.53	−0.16	30.38	1st	28.56	20th.
St. Paul [1]	29.57	−0.09	30.40	9th	28.46	24th.
Kodiak [1]	29.51	−0.08	30.26	10th	28.18	20th.
Midway Island [1]	30.06	+0.01	30.20	29th	29.80	9th.
Honolulu [2]	30.00	0.00	30.10	2d	29.87	9th.
Juneau [2]	29.82	−0.05	30.53	10th	29.00	6th.
Tatoosh Island [2 3]	30.03	0.00	30.32	11th	29.24	3d.
San Francisco [2 3]	30.02	+0.02	30.21	14th	29.58	11th.
San Diego [2 3]	29.95	+0.02	30.15	14th	29.57	11th.

[1] P. m. observations only.
[2] A. m. and p. m. observations.
[3] Corrected to 24-hour mean.

October was the stormiest month since February, 1928, along the upper steamship routes. Whole storm to hurricane wind velocities are reported to have occurred near the fiftieth parallel, between 140° and 175° west longitudes on the 9th, 16th, 20th, and 31st, and whole gales on other dates in northern waters east and west of the one hundred and eightieth meridian. Gales of force 11 also occurred considerably to the southward of the fiftieth parallel near midocean on the 8th and 31st. All these gales but one were attributable directly to the activities of the Aleutian cyclone. That of the 8th, near 36° N., 170° W., was due to a storm that was first observed that same morning east of Midway Island. The storm area had spread north to the Aleutians late on the 9th, and by the 11th, with apparently lessened energy, lay over the eastern part of Bering Sea, whence it crossed Alaska to northwestern Canada.

The region of most frequent storminess was immediately south of the central Aleutians, between 180° and 170° W., where gales of force 8 and upward occurred on 20 to 25 per cent of the days. Fresh gales blew off the California coast on the 11th and 12th, and moderate northers occurred in the Gulf of Tehuantepec on several of the last days of the month.

At least three tropical cyclones of considerable severity formed this month as described by Rev. José Coronas, S. J., of the Philippine weather bureau, in the subjoined article. One of the United States Weather Bureau's reporting vessels, the American steamer *Golden Sun*, passed through the northern edge of the second typhoon on the 6th, near 39° N., 150° E., encountering a gale of force 11, NNE., at a considerable distance from the storm center. Beside the three enumerated, a fourth typhoon, that of the 17th to 19th, is shown on the Tokyo weather charts as coming up from the south of Japan. It passed off the southeastern coast of Honshu late on the 18th, going northeastward. The American steamer *Astral* was caught in this cyclone near 34° N., 150° E., on the 18th, but upon receipt of typhoon warnings broadcast from the Chosi radio station, she changed her course and evaded the storm center toward which she had earlier been steering, thus escaping with only a whole gale.

Two tropical cyclones occurred in Mexican waters, thus increasing the known number for 1928 to nine. Of the earlier there is record for the 7th, furnished by Capt. Philip G. Beck, master of the American steamer *Santa Veronica*, Balboa to Hilo, which encountered fresh to whole south to southwest gales from 6 a. m. until midnight, between latitudes 15° 15′ and 16° N., longitudes 109° and 112° 30′ W. The following is quoted from a report of Captain Beck to the Hydrographic Office:

> On the morning of the 7th at 6 o'clock the storm broke * * *. Through radio communication with the master of the American steamer *Invincible*, he reports at 8 p. m., October 7, barometer 29.60 wind SSW., hurricane force, and a heavy SW. sea, and at 11 p. m., same date, barometer 29.78, wind and sea moderating. This showed that the storm was moving northwest, as the *Invincible* was about 100 miles west by north of the *Santa Veronica* * * *. All indications seemed to show storm moving northwest ahead of the ship and at about 10 miles per hour.

The second cyclone was encountered by the British steamer *Lowther Castle*, Panama to Honolulu, during the 15th and 16th, and slightly to the westward of the *Invincible's* storm. Moderate to fresh gales only were experienced, these occurring between 8 p. m. and 4 a. m., blowing from southerly and finally from northeasterly directions, lowest pressure 29.48 inches, at 2 a. m., in 16° 34′ N., 113° 29′ W.

Easterly trades prevailed at Honolulu in October, except on the last three days, when moderate konas occurred. The maximum velocity was 24 miles from the east on the 4th.

Fog decreased greatly in northern waters since September, being reported on not more than four days in any 5-degree square, except along the American coast, where it occurred on approximately 25 per cent of the days off Washington, and on 40 to 45 per cent off central California.

Waterspout.—Reported by Mr. J. G. Hill, second officer and observer of the British steamer *Bolton Castle*, Honolulu toward Manila:

> On October 11, at 3 p. m. a waterspout was observed about a mile to starboard of the ship, latitude 12° 48′ N., longitude 122° 56′ E. The spout rose to a height of approximately 200 feet, entering dense nimbus cloud, and gradually narrowed to a column seemingly not more than 10 feet in diameter; blue-gray in color and twisted toward its upper end. At the base of the spout spray rose to the height of 20 feet. No horizontal motion was evident. The spout was visible for fully three minutes, and was then overtaken by a rain squall, which approached from northward. Then followed half an hour torrential rain, with thunder at times, at the end of which no trace of spout was visible * * * Barometer remained steady throughout at 29.80, corrected, wind N. by E.

TYPHOONS AND DEPRESSIONS

THREE SEVERE TYPHOONS IN THE FAR EAST DURING OCTOBER, 1928

By Rev. José Coronas, S. J.

[Weather Bureau, Manila, P. I.]

Prescinding from eight or nine depressions or typhoons of not so much importance or of rather doubtful or indefinite tracks, we will mention here only three severe typhoons that visited the Far East during the month of October. One of them traversed the Philippines on October 1, although at that time it was only a shallow depression of little importance.

Typhoon of the China Sea and Indo-China, October 2 to 4.—This typhoon was shown for the first time in our weather maps of September 29 about 350 miles to the east of northern Luzon. It seems to have been at that time only a depression, which moved westward and traversed northern Luzon on October 1. Once in the China Sea it soon developed into a severe typhoon, and as such, it could be seen on the coast of central Indo-China in the morning of October 3, the barometer at Donghoi having fallen to 739.5 mm. (29.11 inches, corrected for gravity) at 4 p. m. of that day with hurricane winds from NNE.

The approximate positions of the center at 6 a. m. of October 1 to 3 were as follows:

October 1, 6 a. m., 122° 30′ longitude E., 17° 35′ latitude N.
October 2, 6 a. m., 116° 50′ longitude E., 17° 30′ latitude N.
October 3, 6 a. m., 109° 30′ longitude E., 16° 45′ latitude N.

Japan typhoon, October 1 to 9.—This typhoon was formed on October 1 to 2 to the S. or SSW. of Guam near 143° or 144° longitude E. and 9° latitude N. It moved northwestward on the 2d, and W. by N. on the 3d, the rate of progress being very great from 6 a. m. of October 3 to 6 a. m. of October 4. Suddenly it remained almost stationary or moved very slowly on the 4th, while recurving to the N. and NE. On the 5th it increased again its rate of progress moving northeastward. On the 6th it began to move N. or N. by E. until it reached Japan in the afternoon or evening of the 8th.

The U. S. S. *Henderson* was near the center of this typhoon on the 6th about 400 miles to the southeast of the Loochoos, the winds having blown from the N. force 9, at 6 p. m. of that day.

The approximate positions of the center at 6 a. m. of October 6 to 8 were as follows:

October 6, 6 a. m., 133° 45′ longitude E., 20° 20′ latitude N.
October 7, 6 a. m., 134° 55′ longitude E., 25° 15′ latitude N.
October 8, 6 a. m., 136° 20′ longitude E., 30° 45′ latitude N.

Ladrones and Bonins typhoon, October 25 to 31.—This was a big typhoon; it appeared on the 25th, at 6 a. m., to the ESE. of Guam near 149° longitude E. and 13° latitude N. It moved WNW. and W. by N. on the 25th and 26th, the center passing 150 miles north of Guam in the early morning of October 26. On the 27th it began to recurve slowly to the north, and on the 30th and 31st it continued recurving to NNE., NE., and ENE. The center passed very near to the north of the Bonins at about noon of the 31st, when the barometer had fallen to 738.5 mm. (29.08 inches, corrected for gravity). It was moving then to ENE.

The approximate positions of the center at 6 a. m. of October 25 to 31 were as follows:

October 25, 6 a. m., 149° 00′ longitude E., 13° 30′ latitude N.
October 26, 6 a. m., 144° 50′ longitude E., 15° 50′ latitude N.
October 27, 6 a. m., 139° 45′ longitude E., 17° 10′ latitude N.
October 28, 6 a. m., 137° 55′ longitude E., 18° 10′ latitude N.
October 29, 6 a. m., 137° 00′ longitude E., 19° 50′ latitude N.
October 30, 6 a. m., 136° 50′ longitude E., 21° 55′ latitude N.
October 31, 6 a. m., 140° 20′ longitude E., 27° 35′ latitude N.

The typhoon could not be noticed in our Weather Maps after October 31, the center having probably gone fast into the Pacific to the ENE. of the Bonins.

CLIMATOLOGICAL TABLES[1]

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, October, 1928

Section	Temperature								Precipitation					
	Section average	Departure from the normal	Monthly extremes						Section average	Departure from the normal	Greatest monthly		Least monthly	
			Station	Highest	Date	Station	Lowest	Date			Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	67.9	+3.5	Selma	97	7	2 stations	32	[2] 24	3.36	+0.74	Decatur	8.25	Seale	0.83
Arizona	63.8	+1.2	Marinette	108	1	Bright Angel Ranger Station.	10	15	1.41	+0.62	Bisbee	5.04	3 stations	0.00
Arkansas	66.3	+4.1	Pine Bluff	100	9	Dutton	27	23	4.74	+1.77	Piggett	11.58	Amity	1.33
California	59.7	−0.8	Amos	110	7	Helm Creek	−1	14	0.37	−0.85	Crescent City	5.98	33 stations	0.00
Colorado	47.6	+0.9	Las Animas	98	8	2 stations	5	[2] 16	1.85	+0.57	Utleyville	5.66	2 stations	0.00
Florida	75.1	+2.0	2 stations	94	[2] 17	Garniers	39	25	3.17	−1.19	Fallsmere	7.31	Moore Haven	0.47
Georgia	68.1	+3.5	do	95	[2] 6	Clayton	27	26	2.20	−0.56	Clayton	7.35	Tifton	0.40
Idaho	47.3	+0.4	do	88	[2] 6	Obsidian	9	[2] 13	1.41	−0.09	Falls Ranger Station.	3.65	Mud Lake	0.19
Illinois	58.1	+2.9	Harrisburg	95	13	Mount Carroll	17	30	4.16	+1.53	Carbondale	8.47	Waterloo	1.70
Indiana	58.2	+3.7	6 stations	93	[2] 11	Wabash	17	30	3.55	+0.86	Washington	7.06	Huntington	1.05
Iowa	54.2	+2.4	3 stations	93	10	5 stations	17	29	3.66	+1.23	Little Sioux	7.38	Red oak	1.46
Kansas	59.0	+1.8	Medicine Lodge	99	[2] 6	8 stations	24	22	2.57	+0.84	Sedan	6.15	Mentor	0.62
Kentucky	61.6	+3.5	Hopkinsville	95	10	Farmers	21	30	3.93	+1.33	Leitchfield	7.11	2 stations	1.98
Louisiana	71.6	+3.6	4 stations	98	[2] 1	Tallulah	33	25	2.77	−0.53	Pearl River	8.70	Cinclare	0.38
Maryland-Delaware	57.8	+1.5	Keedysville, Md	90	13	Oakland, Md	13	30	1.03	−1.83	Easton, Md	2.27	Salisbury, Md	0.19
Michigan	51.0	+2.1	Morenci	91	11	Ruse (near)	12	30	3.84	+1.15	Chatham	6.85	Eloise	1.33
Minnesota	46.6	+1.0	Tracy	93	10	3 stations	8	29	2.19	+0.38	Taylors Falls	4.77	Warroad	0.18
Mississippi	69.2	+4.0	Holly Springs	100	10	2 stations	33	[2] 25	1.99	−0.69	Holly Springs	5.21	Pontotoc	0.33
Missouri	60.9	+3.5	4 stations	94	[2] 8	Goodland	22	31	3.83	+1.08	Dexter	8.97	Edgerton	0.79
Montana	43.2	−1.0	2 stations	88	9	Harlowton	−3	29	0.93	−0.07	Mystic Lake	3.82	Malta	0.03
Nebraska	52.2	+1.3	McCook	98	9	2 stations	18	[2] 29	2.85	+1.29	Geneva	9.49	Fort Robinson	0.58
Nevada	51.7	+0.5	Las Vegas	99	1	Rye Patch	9	13	0.43	−0.26	Kimberly	2.35	2 stations	0.00
New England	50.3	+0.8	3 stations	90	12	Pittsburg (a) N. H	3	30	2.51	−1.06	Pittsburg (b) N. H	8.13	Otis, Mass	0.50
New Jersey	56.1	+1.3	Little Falls	90	12	Belleplain	16	30	1.19	−2.56	Hightstown	2.58	Asbury Park	0.24
New Mexico	55.7	+2.0	Nara Vista	97	[2] 6	Selsor Ranch	9	24	2.32	+1.06	Pennington (near)	7.88	Tierra Ammarilla	0.10
New York	51.9	+2.0	Poughkeepsie	90	[2] 12	2 stations	4	30	2.67	−0.55	Allegany State Park	6.56	Rifton	0.07
North Carolina	62.4	+2.3	Lumberton	91	[2] 6	Mount Mitchell	20	[2] 26	2.55	−0.61	Highlands	10.67	Mount Holly	0.47
North Dakota	43.5	−0.3	Wahpeton	85	10	3 stations	3	[2] 29	0.41	−0.59	Wahpeton	1.80	3 stations	0.00
Ohio	57.3	+3.4	2 stations	93	13	4 stations	16	[2] 30	2.58	−0.13	Wilmington	5.29	Defiance	1.08
Oklahoma	66.6	+5.0	do	101	[2] 1	Goodwell	25	21	3.50	+0.33	Atoka	8.48	Frederick	0.75
Oregon	50.3	0.0	Andrews	92	1	2 stations	−1	21	1.83	−0.43	Valsetz	7.90	2 stations	0.09
Pennsylvania	55.1	+2.7	Claysville	91	11	do	15	[2] 27	1.78	−1.40	2 stations	5.24	Hamburg	0.43
South Carolina	66.4	+2.7	Summerville	92	7	Caesars Head	32	31	1.91	−1.03	Caesars Head	6.61	Summerville	0.62
South Dakota	48.8	+0.4	2 stations	97	10	3 stations	12	[2] 21	1.56	+0.23	Vermilion	5.42	3 stations	0.10
Tennessee	62.7	+3.2	Carthage	96	14	Rugby	25	26	5.18	+2.36	Tullahoma	11.15	Copperhill	2.24
Texas	70.8	+3.3	Henrietta	104	1	Spearman	27	22	1.99	−0.60	Winfield (near)	13.05	5 stations	0.00
Utah	50.4	+1.8	St. George	93	[2] 6	4 stations	11	[2] 21	1.67	+0.27	Trout Creek Ranger Station.	8.70	Black Rock	0.08
Virginia	59.0	+1.6	Saltville	92	14	Burkes Garden	17	30	1.28	−1.75	Marion	4.12	Powhatan	0.13
Washington	48.9	−0.2	Mottinger	87	8	2 stations	12	[2] 20	3.77	+0.50	Forks	17.88	Odessa	0.14
West Virginia	56.7	+1.6	Charleston	94	[2] 12	Pickens	12	30	1.98	−0.97	2 stations	3.26	Perry	0.58
Wisconsin	49.6	+1.6	Blair	90	10	2 stations	10	[2] 29	3.98	+1.41	Oconto	7.36	Stanley	2.23
Wyoming	43.2	+0.5	2 stations	88	[2] 7	Diversion Dam	4	13	1.38	+0.19	Lander	3.62	Shoshone Dam	0.14
Alaska (September)	42.4	−1.4	Calder	78	23	Eagle	13	18	3.74	+0.33	Speel River	20.09	Eagle	0.66
Hawaii	74.1	+0.3	Kaanapali	96	[2] 4	Volcano Observatory.	52	1	4.15	−1.81	Papaikou (Mauka)	26.28	5 stations	0.00
Porto Rico	78.3	+0.1	San German	96	2	Guineo Reservoir	52	18	7.59	−0.72	Maricao	21.90	San Francisco	1.15

[1] For description of tables and charts, see Reviews, January, 1928, p. 29.

[2] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, October, 1928*

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature: Departure from normal	Temperature: Maximum	Temperature: Date	Temperature: Mean maximum	Temperature: Minimum	Temperature: Date	Temperature: Mean minimum	Temperature: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with .01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles.								0-10	In.	In.
New England							52.6	+1.5										75	1.95	−1.3										4.9		
Eastport	76	67	85	29.95	30.04	+0.04	47.3	−0.2	66	6	54	22	30	40	20	44	39	75	2.66	−0.9	13	6,853	w.	30	e.	18	7	7	17	6.7	T.	0.0
Greenville, Me	1,070	6	----	28.87	30.05	------	43.6	------	70	19	53	11	31	34	32	----	----	----	3.84	------	12	------	nw.	----	----	----	8	6	17	----	1.0	----
Portland, Me	103	82	117	29.97	30.09	+.05	51.0	+1.1	76	12	60	22	30	42	30	46	41	72	2.26	−0.9	12	5,425	sw.	28	ne.	13	13	5	13	5.2	T.	0.0
Concord	289	70	79	29.76	30.07	+.02	50.1	+0.4	87	12	63	19	31	38	44	----	----	----	0.89	−2.0	7	3,469	nw.	19	nw	7	15	6	10	4.5	T.	0.0
Burlington	403	11	48	29.62	30.06	+.02	49.6	+0.4	83	12	59	23	30	41	35	----	----	----	2.45	−0.5	10	7,843	s.	44	s.	23	7	7	17	6.8	T.	0.0
Northfield	876	12	60	------	30.09	+.05	47.2	+1.7	83	12	59	14	30	36	42	----	----	82	1.80	−0.7	12	3,504	s.	26	sw	9	6	11	14	6.7	0.3	0.0
Boston	125	115	188	29.95	30.09	+.04	56.6	+3.0	88	12	66	28	30	47	35	50	45	70	2.88	−0.3	7	6,005	sw	25	n.	13	15	10	6	4.3	T.	0.0
Nantucket	12	14	90	30.09	30.10	+.05	55.2	+1.0	75	12	62	30	30	49	21	51	47	76	0.61	−2.8	9	9,919	sw.	36	sw.	9	11	12	8	5.0	0.0	0.0
Block Island	26	11	46	30.07	30.10	+.05	55.3	+0.4	73	12	61	32	30	50	16	51	47	75	1.75	−1.8	7	11,158	s.	38	w.	29	13	12	6	4.4	0.0	0.0
Providence	160	215	251	29.92	30.10	+.05	55.2	+3.0	87	12	64	27	30	46	31	49	44	69	3.63	+0.5	9	7,121	nw.	31	nw.	7	16	11	4	3.4	0.0	0.0
Hartford	159	122	----	29.94	30.11	+.05	55.3	+4.1	88	12	65	27	30	45	33	----	----	----	1.09	−2.4	7	------	s.	----	----	----	19	6	6	3.1	T.	0.0
New Haven	106	74	153	30.01	30.12	+.06	55.4	+1.6	87	12	64	28	30	46	29	51	48	81	1.38	−2.3	6	5,391	s.	26	s.	9	16	12	3	3.5	T.	0.0
Middle Atlantic States							58.3	+1.9										76	1.02	−2.1										4.6		
Albany	97	102	115	29.99	30.10	+.04	54.2	+2.1	85	12	64	25	30	45	34	48	44	76	0.38	−2.4	8	4,774	sw.	26	s.	22	18	7	6	3.6	T.	0.0
Binghamton	871	10	84	29.17	30.11	+.05	53.2	+3.2	86	12	64	23	30	43	42	----	----	----	1.25	−1.9	12	3,615	nw.	21	sw.	23	11	5	15	5.9	0.2	0.0
New York	314	414	454	29.80	30.14	+.08	57.8	+1.5	80	18	66	31	30	50	25	51	45	69	1.27	−2.3	5	10,673	sw.	42	nw.	25	13	15	3	4.3	T.	0.0
Bellefonte	1,050	5	36	29.01	30.13	------	51.9	------	84	12	64	19	27	40	46	47	44	82	1.26	------	9	------	w.	----	----	----	7	9	15	6.1	T.	0.0
Harrisburg	374	94	104	29.76	30.16	+.08	56.8	+2.0	85	12	66	29	27	48	31	50	46	74	0.80	−2.2	5	3,871	s.	23	sw.	18	10	11	10	5.2	T.	0.0
Philadelphia	114	123	367	30.03	30.16	+.09	59.9	+2.1	86	13	68	36	27	52	26	53	50	76	0.73	−2.1	4	6,448	sw.	29	n.	29	13	11	7	4.0	0.0	0.0
Reading	325	81	98	29.79	30.15	------	57.8	------	85	12	67	31	27	48	31	50	46	72	1.81	−1.4	5	3,657	sw.	21	nw.	25	13	10	8	4.7	0.0	0.0
Scranton	805	111	119	29.27	30.14	+.07	54.2	+2.3	84	12	64	27	27	44	37	48	44	76	0.66	−2.2	7	4,256	sw.	21	nw.	28	10	6	15	6.0	T.	0.0
Atlantic City	52	37	172	30.09	30.15	+.08	59.0	+2.1	83	13	66	32	30	52	22	54	50	76	1.38	−1.8	7	9,932	s.	35	s.	28	16	14	1	3.0	0.0	0.0
Cape May	17	13	49	------	------	------	58.6	−1.0	80	13	66	30	27	51	25	54	52	81	1.11	------	5	------	s.	----	----	----	17	13	1	----	0.0	0.0
Sandy Hook	22	10	55	30.11	30.13	------	58.2	------	82	12	65	36	30	52	23	52	48	73	1.22	------	5	9,685	sw.	37	sw.	9	13	14	4	3.8	0.0	0.0
Trenton	190	159	183	29.93	30.14	------	57.4	------	84	12	67	30	27	48	31	52	49	79	1.58	−1.8	6	5,852	sw.	26	sw.	18	14	8	9	4.2	0.0	0.0
Baltimore	123	100	215	30.02	30.15	+.07	60.7	+2.5	88	13	70	34	30	52	28	53	49	71	0.26	−2.6	4	5,642	s.	26	nw.	24	17	5	9	4.1	0.0	0.0
Washington	112	62	85	30.04	30.16	+.08	59.9	+2.5	88	13	70	32	30	50	31	53	50	78	0.67	−2.2	4	3,459	s.	22	nw.	25	15	8	8	4.6	0.0	0.0
Cape Henry	18	8	54	30.13	30.15	------	64.2	------	85	18	70	44	30	58	21	59	55	76	0.97	−2.0	5	8,241	ne.	40	nw.	24	15	9	7	3.9	0.0	0.0
Lynchburg	681	153	188	29.42	30.17	+.08	60.1	+1.6	87	13	70	27	30	50	37	53	50	78	0.65	−2.5	6	3,663	sw.	22	nw.	25	9	10	12	5.2	0.0	0.0
Norfolk	91	170	205	30.08	30.18	+.11	64.6	+2.1	83	17	72	39	30	57	23	57	53	76	1.24	−1.8	6	7,390	s.	29	n.	24	13	13	5	4.2	0.0	0.0
Richmond	144	11	52	30.03	30.18	+.10	61.4	+1.8	84	17	71	32	30	52	32	54	51	79	0.40	−3.8	4	4,346	sw.	21	w.	23	15	5	11	4.5	0.0	0.0
Wytheville	2,304	49	55	27.80	30.17	+.08	55.6	+2.0	82	14	66	24	30	45	37	50	48	83	2.32	−0.5	8	2,896	w.	22	w.	25	12	9	10	5.1	0.0	0.0
South Atlantic States							66.9	+2.7										80	1.66	−1.7										4.5		
Asheville	2,253	70	84	27.82	30.17	+.08	58.2	+2.9	82	14	68	35	29	49	33	52	49	80	3.77	+1.3	8	5,220	se.	27	n.	23	14	9	8	4.9	T.	0.0
Charlotte	779	55	62	29.33	30.17	+.09	64.6	+2.9	87	6	74	39	31	55	26	58	56	83	1.13	−1.8	5	2,667	ne.	14	w.	25	13	10	8	4.6	0.0	0.0
Hatteras	11	11	50	30.14	30.14	+.08	67.6	+1.7	83	9	73	50	30	62	22	63	60	78	1.31	−3.6	6	8,091	ne.	34	n.	31	16	11	4	4.1	0.0	0.0
Raleigh	376	103	110	29.77	30.18	+.11	64.0	+2.0	84	17	73	36	30	55	25	57	54	78	1.44	−2.1	6	3,912	ne.	22	nw.	25	11	12	8	4.7	0.0	0.0
Wilmington	78	81	91	30.08	30.17	+.11	67.2	+1.9	89	14	75	45	27	59	28	61	59	82	1.21	−2.1	5	3,937	ne.	17	e.	8	15	14	2	3.7	0.0	0.0
Charleston	48	11	92	30.09	30.14	+.08	70.4	+2.6	86	10	76	46	30	64	21	66	64	86	1.07	−2.2	3	7,149	ne.	25	n.	24	11	18	2	4.3	0.0	0.0
Columbia, S. C	351	41	57	29.78	30.16	+.09	67.2	+2.9	88	14	76	41	30	58	28	59	56	75	1.70	−1.2	5	3,906	ne.	19	sw.	23	14	12	5	4.2	0.0	0.0
Due West	711	10	55	29.42	30.20	------	65.0	------	87	6	75	39	25	55	32	----	----	----	1.78	------	6	5,030	e.	19	w.	25	14	10	7	4.3	0.0	0.0
Greenville, S. C	1,039	139	146	29.07	30.16	------	64.8	+4.6	86	14	73	39	31	56	26	57	53	73	1.84	------	8	5,219	ne.	25	w.	25	15	8	8	4.1	0.0	0.0
Augusta	182	62	77	29.94	30.14	+.07	69.2	+3.9	90	14	79	43	31	60	27	61	58	77	1.91	−0.6	8	3,100	ne.	16	se.	22	10	15	6	4.7	0.0	0.0
Savannah	65	150	194	30.06	30.14	+.09	70.4	+2.5	86	7	78	46	31	63	23	64	62	82	0.77	−2.2	7	6,703	ne.	22	e.	12	11	7	13	5.4	0.0	0.0
Jacksonville	43	209	245	30.05	30.10	+.08	72.7	+1.6	87	18	79	50	31	66	22	67	64	82	2.33	−2.1	9	6,773	ne.	25	ne	12	12	11	8	4.6	0.0	0.0
Florida Peninsula							78.1	+1.3										77	3.69	−2.3										4.7		
Key West	22	10	64	29.97	29.99	+.05	79.6	+0.5	87	5	84	70	25	75	16	73	71	77	4.55	−1.4	13	6,314	e.	24	se.	13	19	9	3	3.9	0.0	0.0
Miami	25	71	164	30.00	30.03	------	78.2	+1.2	86	2	83	62	25	74	17	72	69	75	3.63	−5.3	16	6,480	e.	26	ne.	10	7	14	10	5.9	0.0	0.0
Tampa	35	79	87	30.02	30.05	+.07	76.5	+2.2	89	2	85	55	25	68	21	69	66	78	2.88	−0.1	9	4,185	ne.	19	e.	12	13	14	4	4.4	0.0	0.0
Titusville	44	5	----	30.01	30.06	------	75.8	------	88	23	83	57	25	69	21	----	----	----	5.59	------	14	------	w.	----	----	----	12	11	8	4.6	0.0	0.0
East Gulf States							69.7	+3.2										77	2.92	0.0										4.1		
Atlanta	1,173	190	216	28.92	30.15	+.08	65.3	+2.3	86	14	74	40	30	57	23	57	53	71	2.19	−0.4	9	6,897	e.	27	nw.	24	13	6	12	4.8	0.0	0.0
Macon	370	78	87	29.74	30.14	+.08	67.8	+3.3	89	6	78	42	25	58	28	61	58	79	2.30	+0.2	9	3,667	e.	19	nw.	24	13	11	7	4.3	0.0	0.0
Thomasville	273	49	58	29.81	30.10	+.06	71.4	+3.2	89	7	81	47	25	62	30	64	61	81	1.66	−1.8	8	2,710	ne.	14	sw.	19	11	10	10	5.1	0.0	0.0
Apalachicola	36	42	49	30.05	30.09	------	72.2	------	85	7	79	51	24	66	26	67	65	83	4.85	------	7	5,569	ne.	28	ne.	11	18	6	7	3.5	0.0	0.0
Pensacola	56	149	185	30.03	30.09	+.06	72.8	+2.9	85	7	78	51	31	68	20	66	63	76	4.93	+0.7	8	8,168	ne.	32	se.	15	14	11	6	4.4	0.0	0.0
Anniston	741	9	57	29.36	30.16	+.09	65.6	+3.2	88	10	77	35	25	54	35	----	----	----	3.93	+1.6	11	3,081	se.	14	w.	22	17	5	9	3.9	0.0	0.0
Birmingham	700	11	48	29.37	30.13	+.06	67.8	+3.0	89	14	78	42	25	58	32	59	56	76	5.02	+2.7	13	4,432	se.	26	se.	17	16	7	8	3.9	0.0	0.0
Mobile	57	125	161	30.03	30.09	+.05	72.6	+3.3	89	9	81	49	24	64	27	65	63	79	3.46	−0.1	7	5,823	se.	29	se.	15	14	13	4	3.9	0.0	0.0
Montgomery	223	100	112	29.87	30.12	+.06	69.8	+3.2	89	5	79	46	31	60	34	----	----	----	2.61	+0.2	9	3,885	se.	18	se.	15	14	10	7	4.3	0.0	0.0
Corinth	469	6	----	------	------	------	66.4	------	93	10	78	36	31	55	40	----	----	----	4.20	------	9	------	se.	----	----	----	8	18	5	----	0.0	0.0
Meridian	375	87	95	29.70	30.10	+.04	68.5	+4.2	91	1	79	41	25	58	35	60	57	77	1.50	−1.2	7	3,100	se.	15	w.	22	17	4	10	3.9	0.0	0.0
Vicksburg	247	65	73	29.82	30.10	+.04	69.8	+3.8	89	9	79	45	30	61	28	61	57	73	1.17	−1.6	8	4,082	se.	27	sw.	5	16	7	8	4.0	0.0	0.0
New Orleans	53	76	84	30.02	30.07	+.04	74.9	+3.9	91	1	82	53	31	67	23	67	64	78	3.36	+0.1	10	4,021	se.	17	e.	25	15	14	2	3.6	0.0	0.0
West Gulf States							71.9	+4.0										75	3.05	+0.1										3.8		
Shreveport	249	77	93	29.80	30.07	+.02	70.4	+3.8	94	1	81	43	31	60	33	62	58	74	4.08	+1.4	9	3,578	se.	20	sw.	16	15	9	7	4.1	0.0	0.0
Bentonville	1,303	11	44	28.75	30.05	.00	63.4	+5.4	89	9	75	32	31	52	37	----	----	----	3.22	------	9	------	s.	----	sw.	----	26	3	2	----	0.0	0.0
Fort Smith	457	79	94	29.57	30.05	.00	67.8	+5.0	92	1	79	38	31	57	36	58	53	69	4.66	+1.7	11	5,139	e.	35	sw.	16	7	18	6	4.8	0.0	0.0
Little Rock	357	136	153	29.70	30.07	+.01	67.1	+3.5	90	9	79	38	31	57	30	59	55	72	3.06	+0.5	9	4,869	s.	36	sw.	15	15	8	8	4.2	0.0	0.0
Austin	605	136	148	29.39	30.07	------	72.7	+4.4	92	6	84	41	23	61	38	64	60	72	0.82	−2.4	4	4,552	se.	26	n.	22	13	11	7	4.3	0.0	0.0
Brownsville	57	53	61	29.92	29.98	------	77.4	+2.5	90	5	86	55	24	69	25	70	68	82	2.93	−0.4	6	3,970	se.	19	w.	16	19	11	1	3.2	0.0	0.0
Corpus Christi	20	11	73	30.00	30.03	+.03	76.8	+4.2	89	1	83	52	24	71	25	71	69	82	4.07	+2.0	6	6,529	se.	26	n.	30	20	8	3	3.1	0.0	0.0
Dallas	512	220	227	29.49	30.04	------	71.0	------	95	1	81	44	23	61	34	----	----	----	4.34	------	11	8,070	se.	39	w.	21	16	10	5	4.0	0.0	0.0
Fort Worth	670	106	114	29.31	30.06	−.02	71.6	+5.3	97	1	83	43	23	61	38	62	57	68	4.15	+1.5	10	6,076	se.	24	s.	21	17	5	9	4.0	0.0	0.0
Galveston	54	106	114	30.00	30.06	+.03	75.6	+2.9	88	7	80	55	31	71	21	69	67	78	3.82	−0.5	5	6,489	se.	26	s.	10	21	7	3	2.9	0.0	0.0
Groesbeck	461	11	56	29.55	30.03	------	71.8	------	95	4	84	38	23	61	39	----	----	----	1.47	------	4	6,489	se.	29	se.		19	9	3	3.1	0.0	0.0
Houston	138	292	314	29.90	30.05	------	74.1	+3.8	94	6	82	49	31	66	28	----	----	----	4.02	+0.4	4	7,626	e.	28	se.	9	16	12	3	3.5	0.0	0.0
Palestine	510	64	72	29.53	30.06	+.03	71.2	+4.0	94	5	82	42	23	61	39	62	58	73	2.94	−0.4	9	4,517	s.	28	se.	10	15	10	6	3.9	0.0	0.0
Port Arthur	34	58	66	30.01	30.05	------	73.9	------	90	6	82	47	23	66	24	68	67	84	2.99	------	8	4,386	s.	20	n.	17	19	9	3	3.1	0.0	0.0
San Antonio	693	119	132	29.30	30.05	+.01	74.0	+4.3	94	1	85	49	23	64	31	65	61	71	1.69	−0.5	3	4,079	se.	19	n.	22	12	15	4	3.9	0.0	0.0
Taylor	583	55	63	29.45	30.06	+.01	72.6	+4.3	93	5	84	40	23	64	36	----	----	----	0.39	−2.2	4	4,904	s.	24	se.	16	15	11	5	3.8	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, October, 1928*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature: Departure from normal	Temperature: Maximum	Temperature: Date	Temperature: Mean maximum	Temperature: Minimum	Temperature: Date	Temperature: Mean minimum	Temperature: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with .01, or more	Wind: Total movement	Wind: Prevailing direction	Maximum velocity: Miles per hour	Maximum velocity: Direction	Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft	In.	In.	In.	° F.	° F.	° F.		° F.	° F.		° F.	° F.	° F.	° F.	%	In.	In.		Miles.								0-10	In.	In.
Ohio Valley and Tennessee							60.5	+2.8										74	3.68	+1.1										5.2		
Chattanooga	762	190	215	29.33	30.14	+0.05	63.8	+1.9	86	14	72	40	31	55	30	56	52	73	5.04	+2.0	10	4,742	se.	26	sw.	22	14	6	11	4.9	0.0	0.0
Knoxville	995	102	111	29.10	30.15	+.06	62.0	+2.1	85	14	72	38	26	52	28	55	52	79	3.81	+1.2	10	3,216	ne.	23	s.	22	12	9	10	5.0	0.0	0.0
Memphis	399	76	97	29.66	30.09	+.02	66.6	+3.3	88	10	75	38	31	58	28	59	55	73	5.15	+2.5	9	4,039	e.	24	nw.	22	17	6	8	4.3	0.0	0.0
Nashville	546	168	191	29.56	30.14	+.06	64.0	+3.0	88	14	74	38	31	54	36	56	52	71	6.82	+4.3	9	5,498	s.	29	s.	22	11	10	10	4.7	0.0	0.0
Lexington	989	193	230	29.08	30.15	+.07	61.0	+3.6	85	13	70	30	30	52	26				2.69	+0.5	9	8,627	sw.	30	sw.	17	17	8	6	3.8	0.0	0.0
Louisville	525	188	234	29.55	30.13	+.05	61.4	+2.1	88	13	71	32	30	52	31	54	50	74	4.45	+1.8	8	6,259	s.	30	s.	5	16	9	6	4.1	0.0	0.0
Evansville	431	76	116	29.67	30.14	+.06	62.8	+3.4	90	13	72	35	31	54	30	55	50	71	6.59	+3.8	8	5,116	s.	22	s.	4	15	8	8	4.5	0.0	0.0
Indianapolis	822	194	230	29.22	30.11	+.04	58.4	+2.7	86	11	67	29	30	50	29	51	46	70	2.93	+0.2	12	7,220	s.	26	w.	24	11	11	9	4.9	0.0	0.0
Royal Center	736	11	55	29.29	30.09		55.6		86	11	66	20	30	45	35				1.74		11	6,131	s.	28	sw.	5	7	9	15	6.0	0.0	0.0
Terre Haute	575	96	129	29.48	30.10		59.3		87	11	68	29	30	50	29	52	48	74	3.73		10	5,598	s.	25	w.	4	12	10	9	5.1	0.0	0.0
Cincinnati	627	11	51	29.45	30.13	+.05	59.8	+4.1	88	13	70	27	30	49	26	52	48	73	3.18	+0.7	7	4,283	s.	22	s.	22	11	10	10	5.1	0.0	0.0
Columbus	822	179	222	29.25	30.13	+.05	58.2	+3.0	86	11	67	30	30	49	32	51	46	71	2.85	+0.4	9	6,541	s.	35	w.	24	7	14	10	5.5	0.0	0.0
Dayton	899	137	173	29.16	30.12		58.7	+3.7	87	11	68	27	30	49	34	51	47	73	2.89	+0.3	9	5,584	sw.	20	w.	16	6	16	9	5.8	0.0	0.0
Elkins	1,947	59	67	28.12	30.19	+.00	54.4	+2.1	84	17	66	17	30	42	41	48	46	85	1.71	-0.7	12	3,008	w.	20	w.	25	5	11	15	6.9	T.	0.0
Parkersburg	637	77	82	29.50	30.16	+.08	59.2	+3.1	87	17	70	25	30	48	35	51	47	75	2.18	-0.3	6	3,292	se.	24	nw.	25	10	7	14	6.0	0.0	0.0
Pittsburgh	842	353	410	29.22	30.13	+.05	57.0	+1.3	83	12	66	32	30	48	34	50	46	71	1.22	-1.3	10	6,578	sw.	34	nw.	24	7	10	14	6.1	T.	0.0
Lower Lake Region							54.8	+2.6										74	2.91	0.0										6.0		
Buffalo	767	247	280	29.24	30.07	+.02	53.2	+1.3	81	4	60	28	30	46	29	49	46	79	2.39	-0.9	14	11,077	sw.	50	w.	19	9	10	12	5.8	0.7	0.0
Canton	448	10	61	29.57	30.05		48.6	+1.4	78	12	58	15	30	39	34				3.89	+0.6	13	6,458	sw.	34	sw.	19	11	9	11	5.4	0.2	0.0
Ithaca	836	5	100	29.17	30.08		51.8		86	12	61	15	30	42	38	46	43	79	2.59	-0.4	12	6,356	s.	36	s.	5	9	8	14	6.1	2.0	0.0
Oswego	335	76	91	29.70	30.07	+.02	52.7	+1.5	82	12	60	22	30	45	30	48	44	75	3.50	+0.2	15	6,597	s.	27	n.	13	8	8	15	6.4	T.	0.0
Rochester	523	86	102	29.51	30.09	+.04	54.2	+2.7	84	12	62	27	30	46	33	48	44	72	2.72	+0.1	15	5,052	sw.	25	w.	9	11	4	16	6.3	1.0	0.0
Syracuse	596	65	97	29.45	30.10	+.04	54.0	+3.0	86	12	62	19	30	46	34				3.66	+0.4	13	4,752	s.	21	nw.	9	7	10	14	6.3	5.2	0.0
Erie	714	130	166	29.31	30.09	+.04	56.6	+3.2	83	11	64	33	27	49	28	50	46	71	3.38	-0.3	12	9,526	s.	36	w.	24	11	9	11	5.6	0.5	0.0
Cleveland	762	190	201	29.27	30.10	+.04	57.4	+3.8	86	11	65	35	29	50	31	50	46	69	3.28	+0.5	15	8,672	s.	56	nw.	24	7	11	13	6.1	T.	0.0
Sandusky	629	5	67	29.41	30.10	+.04	57.4	+3.1	88	11	67	28	30	48	35				3.05	+0.6	12	5,765	sw.	34	nw	24	6	14	11	6.0	0.0	0.0
Toledo	628	208	243	29.41	30.10	+.05	56.5	+3.1	87	11	65	29	30	48	31	50	46	75	1.73	-0.6	14	8,408	sw.	37	sw.	18	9	9	13	5.3	0.0	0.0
Fort Wayne	856	113	124	29.15	30.08		56.6	+2.9	88	11	66	27	30	48	36	50	46	73	1.83		11	5,658	sw.	27	nw.	24	7	8	16	6.3	0.0	0.0
Detroit	730	218	258	29.29	30.09	+.04	55.4	+2.9	86	11	63	28	29	48	28	49	46	76	1.82	-0.6	14	6,040	sw.	33	sw.	18	9	8	14	6.0	T.	0.0
Upper Lake Region							50.1	+1.6										80	3.36	+0.7										6.8		
Alpena	609	13	92	29.35	30.02	-.01	49.0	+1.9	87	11	57	27	30	41	32	45	43	82	3.18	+0.5	16	7,474	sw.	30	se.	10	7	6	18	6.8	T.	0.0
Escanaba	612	54	60	29.34	30.01	.00	47.2	+1.2	71	11	54	24	30	41	25	43	40	82	2.91	+0.3	14	7,335	s.	30	n.	12	6	7	18	6.7	T.	0.0
Grand Haven	632	54	89	29.36	30.04	+.01	52.4	+1.7	78	3	59	26	30	46	33	49	46	80	2.94	-0.1	15	7,959	s.	32	w.	27	7	7	17	6.7	T.	0.0
Grand Rapids	707	70	87	29.29	30.06	+.02	54.2	+3.0	85	11	62	29	30	46	33	48	44	75	3.27	+0.5	12	3,668	s.	22	nw.	24	3	9	19	7.5	T	0.0
Houghton	668	64	99	29.25	29.98	-.02	45.8	+0.1	72	4	51	29	28	40	26				3.75	+0.6	15	6,494	w.	31	w.	5	1	7	23	8.4	T	0.0
Lansing	878	6	49	29.12	30.07		52.0	+1.7	82	11	61	20	30	42	34	48	46	87	3.96	+1.5	17	3,440	s.	18	nw.	25	9	12	10	5.6	T.	0.0
Ludington	637	60	66	29.32	30.02		51.4		75	11	57	29	30	46	30	48	45	79	3.92		12	7,575	s.	36	s.	4	7	10	14	6.3	T.	0.0
Marquette	734	77	111	29.19	30.00	-.01	47.6	+0.9	86	11	54	22	30	41	30	42	39	81	5.10	+2.3	21	7,108	w.	32	sw.	11	2	4	25	8.7	1.9	0.0
Port Huron	638	70	120	29.37	30.07	+.03	53.2	+2.7	85	11	62	24	29	45	27	48	45	79	1.70	-0.8	14	7,271	s.	36	nw.	24	7	18	6	5.5	T	0.0
Sault Sainte Marie	614	11	52	29.31	30.01	.00	46.0	+1.4	76	11	53	25	9	39	28	43	41	87	5.12	+1.9	19	5,724	nw.	31	nw.	5	3	8	20	8.2	1.1	0.0
Chicago	673	7	131	29.34	30.07	+.03	56.5	+2.5	87	11	64	30	29	49	30	50	46	73	2.74	+0.2	12	7,057	s.	25	sw.	6	11	4	16	5.9	0.0	0.0
Green Bay	617	109	141	29.35	30.01	-.01	50.2	+1.7	82	11	58	24	29	42	32	45	42	79	3.71	+1.3	14	7,586	s.	33	nw.	24	6	9	16	6.6	T.	0.0
Milwaukee	681	125	221	29.30	30.04	+.01	53.4	+2.3	86	11	61	28	29	46	31	48	44	75	3.05	+0.7	11	9,100	sw.	34	n.	12	9	6	16	6.3	0.0	0.0
Duluth	1,133	5	47	28.78	30.01	+.01	44.0	-0.1	69	8	52	16	29	36	26	40	37	84	2.16	-0.2	11	8,278	nw.	35	nw.	4	8	12	11	6.1	T.	0.0
North Dakota							43.8	+0.5										66	0.38	-0.8										5.1		
Moorhead	940	50	58	28.99	30.02	+.02	45.7	+1.2	79	3	56	17	30	35	40	39	33	68	1.01	-0.7	4	5,554	n.	24	nw.	8	8	9	14	6.0	T.	0.0
Bismarck	1,674	8	57	28.24	30.05	+.06	45.4	+0.5	77	9	58	8	29	33	38	37	31	65	0.19	-0.8	4	5,835	nw.	26	nw.	8	11	14	6	4.7	T.	0.0
Devils Lake	1,478	11	44	28.43	30.04	+.05	41.4	+0.9	75	3	54	11	31	29	38	34	28	66	0.06	-1.2	3	6,131	nw.	28	nw.	23	11	9	11	5.0	T.	0.0
Ellendale	1,457	10	56	28.45	30.03		45.0		84	3	57	16	29	34	46				1.42		6	8,846	nw.	37	s.	3	10	8	13	5.5	0.0	0.0
Grand Forks	833	12	67				43.2		83	3	55	13	29	32	38	36			0.53		5		nw.		s.	3	8	12	11		0.0	0.0
Williston	1,878	41	48	28.05	30.06	+.08	42.8	-0.6	75	2	55	15	29	31	40	35	28	63	0.24	-0.6	4	4,945	n.	28	w.	18	12	13	6	4.5	1.9	T.
Upper Mississippi Valley							55.8	+2.7										75	3.57	+1.2										5.5		
Minneapolis	918	102	208	29.02	30.01		50.6	+1.7	90	10	59	23	29	42	36				3.17	+1.1	12	8,043	s.	32	nw.	24	7	10	14	6.3	0.0	0.0
St. Paul	837	236	261	29.09	30.00	-.01	49.8	+1.2	88	10	58	22	29	41	36				2.46	+0.3	12	8,517	w.	38	s.	4	7	11	13	6.0	T.	0.0
La Crosse	714	11	48	29.25	30.02	.00	52.0	+1.7	86	11	62	22	29	42	35	47	43	77	3.06	+0.7	10	3,076	s.	15	nw.	27	12	5	14	6.0	0.0	0.0
Madison	974	70	78	29.00	30.05	+.02	52.4	+2.1	84	11	60	27	30	45	33	47	43	76	3.34	+0.9	12	5,877	nw.	26	sw.	21	10	8	13	5.8	0.0	0.0
Wausau	1,247	4	64	28.66	30.01		48.4		82	10	57	23	29	40	40				4.52		12	4,113	s.	22	nw.	6	6	5	20	7.3	T.	0.0
Charles City	1,015	10	51	28.96	30.05	+.03	51.1	+2.5	87	10	62	21	29	41	36	45	42	79	3.33	+1.3	8	4,217	se.	23	sw.	10	14	5	12	4.8	0.0	0.0
Davenport	606	71	79	29.39	30.05	+.01	56.5	+2.8	85	10	66	28	29	48	28	50	46	74	3.44	+1.0	13	4,454	s.	23	w.	4	13	5	13	5.4	0.0	0.0
Des Moines	861	84	97	29.12	30.04	+.01	55.6	+2.2	88	10	66	29	29	46	36	49	44	71	3.08	+0.6	9	4,758	n.	35	sw.	10	12	5	14	5.6	0.0	0.0
Dubuque	700	81	96	29.29	30.04	.00	53.8	+1.9	85	11	63	25	30	45	35	48	44	74	3.46	+1.0	12	4,134	s.	28	sw.	4	9	8	14	6.0	0.0	0.0
Keokuk	614	64	78	29.40	30.07	+.02	58.5	+3.1	86	12	68	31	29	50	28	51	46	72	5.91	+3.6	9	4,546	s.	25	sw.	4	10	8	13	5.6	0.0	0.0
Cairo	358	87	93	29.72	30.11	+.04	63.4	+3.0	88	10	72	38	31	55	29	56	52	74	5.13	+2.4	8	4,666	s.	20	se.	22	13	8	10	4.9	0.0	0.0
Peoria	609	11	45	29.42	30.09	+.04	57.0	+5.0	87	11	67	26	30	47	32	50	47	79	3.66	+1.4	10	3,797	s.	18	sw.	8	14	7	10	4.7	0.0	0.0
Springfield, Ill	636	10	91	29.40	30.08	+.03	58.6	+2.8	85	12	67	32	29	50	29	53	49	79	3.72	+1.2	9	5,258	s.	22	s.	4	11	10	10	5.2	0.0	0.0
Hannibal	534	74	109	29.48	30.06	+.01	60.2	+4.0	89	10	70	33	31	50	32				3.97	+2.3	9	5,149	s.	32	sw.	4	14	7	10	4.9	0.0	0.0
St. Louis	568	265	303	29.47	30.08	+.02	62.2	+3.9	88	12	71	37	29	54	27	54	48	67	2.24	-0.5	10	8,074	s.	37	s.	8	17	5	9	4.3	0.0	0.0
Missouri Valley							56.0	+2.3										66	2.74	+0.8										4.8		
Columbia, Mo.	784	6	84	29.22	30.06	+.01	60.8	+4.2	89	10	71	34	23	51	33				2.86	+.04	9	4,609	se.	28	w.	4	9	15	7	4.8	0.0	0.0
Kansas City	963	161	181	29.01	30.05	+.01	60.8	+3.1	91	8	70	36	29	51	34	52	46	66	2.64	-0.3	10	6,277	s.	27	w.	4	10	12	9	4.6	0.0	0.0
St. Joseph	967	11	49	29.00	30.04		59.0		90	8	70	32	31	48	34	50	45	70	3.51		11	5,133	se.	33	nw.	4	14	8	9	4.4	0.0	0.0
Springfield, Mo.	1,324	98	104	28.68	30.08	+.03	62.7	+4.5	86	12	72	36	31	54	31	54	49	68	1.69	-1.1	11	6,737	s.	32	s.	8	16	12	3	3.1	0.0	0.0
Iola	984	11	50	28.99	30.03	+.01	61.8	+4.0	90	8	74	35	31	50	38				4.87	+2.2	13	3,771	s.	22	n.	1	14	7	10	4.8	0.0	0.0
Topeka	987	92	107				60.0	+3.0	93	8	71	33	31	49	37				1.47	-0.4	8	6,284	s.	30	nw.	4	16	5	10	4.1	0.0	0.0
Lincoln	1,189	11	81	28.77	30.03	.00	55.5	+1.3	91	10	66	34	22	44	43	47	41	67	4.21	+2.4	11	6,244	s.	31	s.	10	13	5	13	5.4	0.0	0.0
Omaha	1,105	115	122	28.86	30.04	+.01	56.2	+1.9	91	10	66	32	29	46	34	48	41	65	3.33	+1.2	8	5,172	nw.	28	nw.	21	15	6	10	4.5	0.0	0.0
Valentine	2,598	47	54	27.32	30.06	+.05	49.6	+0.3	91	10	62	23	22	38	48	40	32	62	1.63	+0.3	10	5,892	n.	31	nw.	18	10	10	11	5.3	4.1	2.5
Sioux City	1,135	94	164	28.83	30.05	+.03	52.8	+1.9	92	10	63	30	29	43	38	45	39	66	3.55	+1.8	8	7,966	nw.	44	sw.	10	13	4	14	5.4	0.0	0.0
Huron	1,306	59	74	28.64	30.06	+.05	49.0	+1.3	92	10	61	23	29	37	47	41	34	66	1.28	0.0	8	6,155	nw.	28	s.	3	13	7	11	5.5	0.2	0.1
Pierre	1,572	70	75		30.06	+.05	50.4	+0.6	93	10	62	25	31	39	44			66	2.29	+1.5	9	5,402	nw.	30	nw.	18	11	8	12		1.7	1.0
Yankton	1,233	49	57	28.70	30.03	+.02	52.1	+1.0	93	10	63	30	29	41	46				3.08	+1.7	7	5,105	nw.	30	s.	11	11	8	12	5.9	T.	T.

TABLE 1.—*Climatological data for Weather Bureau stations, October, 1928*—Continued

District and station	Elevation of instruments			Pressure			Temperature of the air												Precipitation			Wind										
	Barometer above sea level	Thermometer above ground	Anemometer above ground	Station reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Total	Departure from normal	Days with .01, or more	Total movement	Prevailing direction	Maximum velocity: Miles per hour	Maximum velocity: Direction	Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles.								0–10	In.	In.
Northern Slope							45.0	−0.3										64	1.37	+0.4										5.8		
Billings	3,140	5																														
Havre	2,505	11	44	27.40	30.06	+0.08	43.1	−1.4	81	9	56	14	30	30	45	35	29	64	0.16	−0.5	4	4,560	sw.	33	sw.	22	6	12	13	6.2	0.5	T.
Helena	4,110	87	112	25.84	30.07	+.04	44.4	−0.5	78	9	54	19	31	35	41	37	30	63	0.26	−0.6	9	5,375	sw.	29	w.	22	3	12	16	6.9	1.3	T.
Kalispell	2,973	48	56	26.97	30.05	+.04	43.2	−0.3	68	9	53	21	12	34	31	38	31	65	0.82	−0.4	9	3,468	nw.	17	nw.	9	12	9	10	5.4	0.0	0.0
Miles City	2,371	48	55	27.53	30.11	+.11	46.4	−0.1	85	9	58	23	31	35	43	38	31	64	1.34	+0.6	6	3,740	s.	24	nw.	17	9	12	10	5.6	3.7	T.
Rapid City	3,259	50	58	26.66	30.10	+.09	46.9	−1.6	84	9	58	23	31	35	39	38	30	58	0.68	−0.4	4	5,272	n.	28	nw.	18	9	12	10	5.2	4.9	2.0
Cheyenne	6,088	84	101	24.04	30.03	+.02	45.0	+0.2	80	9	56	15	31	34	37	36	28	60	1.27	+0.3	10	7,978	w.	36	w.	4	12	7	12	5.4	4.8	3.0
Lander	5,372	60	68	24.68	30.08	+.04	43.5	0.0	79	9	56	18	12	30	42	36	29	66	3.62	+2.6	5	2,838	sw.	35	sw.	10	11	13	7	5.4	27.6	5.6
Sheridan	3,790	10	47	26.14	30.09		44.2		83	9	58	19	30	30	48	36	29	67	2.32		8	2,788	nw.	30	nw.	17	8	13	10	5.9	16.8	4.4
Yellowstone Park	6,241	11	48	23.92	30.09	+.07	40.2	−1.3	67	9	50	15	31	30	31	33	28	68	1.57	+0.4	10	5,485	sw.	27	sw.	9	6	8	17	7.0	10.0	0.5
North Platte	2,821	11	51	27.10	30.04	+.02	52.2	+2.5	90	10	65	24	22	40	46	42	35	64	2.61	+1.5	7	4,976	n.	21	n.	16	13	7	11	5.0	1.9	0.0
Middle Slope							57.9	+2.0										62	2.09	+0.6										4.5		
Denver	5,292	106	113	24.76	30.02	+.01	50.8	−0.4	85	3	62	24	31	39	37	41	31	57	1.97	+0.9	10	4,523	s.	27	nw.	31	14	6	11	5.1	7.7	T.
Pueblo	4,685	80	86	25.32	30.00	+.01	52.6	+0.6	87	9	67	26	22	38	47	40	29	50	0.15	−0.6	6	4,165	nw.	30	sw.	7	16	5	10	4.4	0.0	0.0
Concordia	1,392	50	58	28.58	30.06	+.03	57.2	+1.3	90	8	69	30	30	46	41	48	42	68	3.01	+1.0	10	5,096	s.	26	s.	10	12	4	15	5.4	T.	0.0
Dodge City	2,509	11	51	27.44	30.05	+.03	57.5	+1.4	92	8	70	29	22	45	37	47	41	66	3.19	+1.9	7	6,178	s.	28	nw.	21	20	2	9	3.5	T.	0.0
Wichita	1,358	139	158	28.59	30.01	−.02	62.2	+3.6	92	4	73	35	30	52	35	52	46	66	1.48	−0.8	9	8,800	s.	48	sw.	7	18	6	7	3.8	0.0	0.0
Broken Arrow	765	11	56	29.22	30.05		65.2		90	9	76	38	31	54	36				4.76		10	7,944	s.	37	sw.	4	7	15	9	5.2	0.0	0.0
Oklahoma City	1,214	10	47	28.74	30.01	−.02	67.2	+5.7	95	4	79	39	22	56	38	55	49	63	2.74	+0.9	5	6,680	s.	26	nw.	21	12	13	6	4.4	0.0	0.0
Southern Slope							66.6	+3.5										64	2.10	+0.2										3.9		
Abilene	1,738	10	52	28.21	30.00	−.01	69.6	+4.2	96	1	82	42	23	58	39	57	51	62	1.52	−1.0	3	6,567	s.	28	w.	21	19	7	5	3.5	0.0	0.0
Amarillo	3,676	10	49	26.30	30.00	.00	61.8	+4.1	90	8	73	33	30	50	35	50	44	64	2.77	+1.1	9	6,444	s.	28	se.	14	13	7	11	4.8	0.0	0.0
Del Rio	944	64	71	28.99	29.97	−.01	72.6	+2.6	90	1	82	48	23	64	28	63	59	69	0.76	−1.2	3	5,808	se.	25	nw.	16	17	9	5	3.7	0.0	0.0
Roswell	3,566	75	85	26.38	29.96	.00	62.6	+3.1	91	6	77	37	22	48	43	51	44	60	3.34	+2.1	7	4,804	s.	25	s.	11	18	6	7	3.6	0.0	0.0
Southern Plateau							62.0	+2.0										51	0.97	+0.4										2.7		
El Paso	3,778	152	175	26.19	29.92	.00	67.8	+4.3	94	5	80	44	18	55	36	52	41	45	1.47	+0.7	7	5,982	e.	33	w.	31	21	7	3	2.6	0.0	0.0
Santa Fe	7,013	38	53	23.30	29.95	−.01	52.6	+2.2	78	6	64	28	17	41	33	41	32	55	1.81	+0.6	9	3,984	se.	25	se.	14	15	9	7	4.4	T.	0.0
Flagstaff	6,907	10	59	23.38	29.94	+.02	48.1	+3.4	78	8	63	23	23	33	48	38		62	2.69		8		nw.				17	11	3		0.0	0.0
Phoenix	1,108	10	82	28.73	29.87	−.01	72.6	+2.0	101	8	87	43	15	58	39	57	46	44	1.51	+1.2	5	2,169	e.	21	w.	20	17	11	3	3.1	0.0	0.0
Yuma	141	9	54	29.72	29.86	−.01	73.2	−0.1	102	8	89	44	15	58	41	58	48	48	0.06	−0.2	1	2,421	w.	21	w.	11	25	6	0	1.4	0.0	0.0
Independence	3,957	6	27	25.97	29.98	+.03	57.6	+0.1	86	8	71	52	1	44	38	43			T.	−0.3	0		nw.				19	7	5	1.8	0.0	0.0
Middle Plateau							51.6	+1.3										48	1.18	+0.3										3.6		
Reno	4,532	74	81	25.48	29.99	.00	51.7	+2.0	82	8	67	24	14	36	43	41	32	52	0.10	−0.3	1	3,616	w.	30	w.	2	19	7	5	3.3	1.1	0.0
Tonopah	6,090	12	20				52.2		75	8	61	26	13	43	26	39	23	35	0.32		4		se.									
Winnemucca	4,344	18	56	25.65	30.05	.00	48.1	−0.2	82	9	65	19	22	31	53	39	29	53	0.58	0.0	4	4,226	ne.	26	nw.	10	16	12	3	3.3	2.2	0.0
Modena	5,473	10	43	24.62	29.95	−.01	49.4	+1.4	81	8	66	23	23	33	48	38	24	45	0.23	−0.6	3	6,291	w.	42	s.	10	17	10	4	3.5	T.	0.0
Salt Lake City	4,360	163	203	25.64	30.00	−.01	53.6	+1.1	81	9	64	34	11	43	37	43	33	50	1.83	+0.4	8	4,615	nw.	34	nw.	10	12	11	8	4.5	T.	0.0
Grand Junction	4,602	60	68	25.39	29.97	−.02	55.0	+2.2	81	7	67	35	15	43	42	44	34	54	3.15	+2.2	9	3,701	se.	28	se.	11	18	7	6	3.6	0.0	0.0
Northern Plateau							51.3	+1.4										58	0.83	−0.4										5.4		
Baker	3,471	48	53	26.48	30.08	.00	47.5	+0.9	75	9	60	19	21	35	39	40	32	57	0.73	−0.2	6	3,907	se.	22	nw.	11	9	13	9	5.3	T.	0.0
Boise	2,739	78	86	27.20	30.06	.00	52.8	+1.7	79	6	65	27	21	41	33	44	35	56	0.78	−0.5	9	2,776	se.	18	nw.	10	11	12	8	5.1	T.	0.0
Lewiston	757	40	48	29.24	30.06	−.01	53.3	+1.8	83	8	65	20	13	42	32				0.94	−0.3	8	1,595	e.	23	nw.	9	10	11	10	5.5	0.0	0.0
Pocatello	4,477	60	68	25.50	30.02	−.02	50.2	+1.8	82	9	62	30	11	38	36	41	33	59	0.97	0.0	9	5,024	se.	36	sw.	10	9	13	9	5.2	1.7	0.0
Spokane	1,929	101	110	27.99	30.05	−.01	49.5	+1.2	72	8	60	25	13	40	34	43	35	61	0.52	−0.6	8	3,669	s.	21	sw.	9	9	8	14	5.9	0.0	0.0
Walla Walla	991	57	65	28.97	30.04	−.03	54.4	+0.9	80	8	64	30	12	45	27	47	39	58	1.04	−0.5	8	2,650	s.	21	w.	9	12	8	11	5.1	0.0	0.0
North Pacific Coast Region							52.5	+0.4										82	4.39	+0.5										7.0		
North Head	211	11	56	29.82	30.04	−.01	51.8	−1.1	61	23	55	42	21	49	13	51	49	91	4.59	+0.5	16	9,739	s.	68	s.	3	6	10	15	6.7	0.0	0.0
Port Angeles	29	8	53		30.07		48.2		63	8	54	34	21	43	19				3.27	+0.7	17	2,839	sw.	25	w.	9	5	4	22		0.0	0.0
Seattle	125	215	250	29.93	30.06	+.01	51.8	+0.4	66	8	56	35	21	47	18	49	46	82	3.19	+0.5	15	5,700	s.	30	sw.	7	2	7	22	8.4	0.0	0.0
Tacoma	194	172	201	29.86	30.07	+.03	52.0	+1.5	68	8	57	32	21	47	22				4.18	+1.0	14	5,234	s.	30	sw.	9	3	5	23	8.4	0.0	0.0
Tatoosh Island	86	9	53	29.93	30.03	+.02	50.7	+0.8	57	5	54	43	21	48	10	49	48	93	11.24	+3.2	21	8,919	E.	50	s.	6	3	7	21	8.1	0.0	0.0
Yakima	1,071	5					51.6		78	8	68	19	13	35	45				0.47		5		sw.				10	12	9	5.3	0.0	0.0
Medford	1,425	4	80	28.55	30.06		53.1		80	8	66	27	13	40	41	47	42	75	1.28		9		n.	21	nw.	11	13	5	13	5.2	0.0	0.0
Portland, Oreg.	153	68	106	29.92	30.08	+.02	54.7	+0.5	74	8	61	35	22	48	27	50	46	75	1.65	−1.5	13	3,674	nw.	19	s.	3	4	8	19	7.4	0.0	0.0
Roseburg	510	75	99	29.53	30.08	.00	54.0	+0.1	80	8	64	30	13	44	39	49	44	73	1.50	−1.1	10	2,115	nw.	23	n.	11	4	10	17	6.9	0.0	0.0
Middle Pacific Coast Region							59.7	−0.7										70	0.53	−0.8										3.9		
Eureka	62	73	89	30.02	30.09	+.03	52.8	−0.8	67	7	58	41	13	48	16	50	49	88	2.21	−0.1	10	3,983	n.	36	n.	11	5	7	19	7.2	0.0	0.0
Red Bluff	330	54	58	29.63	29.98	−.05	63.3	−1.0	94	8	78	40	13	49	42	53	44	54	0.14	−1.2	2	3,412	nw.	24	nw.	10	21	6	4	2.8	0.0	0.0
Sacramento	69	106	117	29.90	29.97	−.02	62.8	−0.1	92	8	75	43	28	50	35	54	46	61	0.15	−0.8	3	4,323	s.	31	nw.	10	22	7	2	2.3	0.0	0.0
San Francisco	155	208	243	29.85	30.02	+.01	59.6	−0.9	87	8	66	49	14	53	30	53	49	76	0.13	−1.0	3	4,681	w.	35	n.	11	16	8	7	4.3	0.0	0.0
San Jose	141	12	110	29.86	30.02		59.8	−0.5	91	8	72	38	14	48	40				0.01	−0.7	1	3,497	nw.	22	nw.	11	17	12	2	3.1	0.0	0.0
South Pacific Coast Region							63.5	−0.8										66	0.14	−0.5										2.9		
Fresno	327	89	98	29.62	29.97	+.01	64.7	+0.7	92	9	78	43	28	51	35	53	42	49	T.	−0.6	0	4,015	nw.	29	nw.	30	25	5	1	1.5	0.0	0.0
Los Angeles	338	159	191	29.60	29.97	+.02	63.7	−1.6	85	17	72	48	13	55	26	55	50	71	0.29	−0.4	2	3,144	sw.	21	nw.	30	19	9	3	3.0	0.0	0.0
San Diego	87	62	70	29.86	29.95	.00	62.2	−1.5	75	17	68	50	14	56	19	57	54	79	0.14	−0.4	1	3,916	nw.	19	s	12	13	14	4	4.1	0.0	0.0
West Indies																																
San Juan, P. R.	82	9	54	29.84	29.92		79.9	+0.1	89	23	85	72	7	74	15				2.47	−3.6	17	6,186	e.	29	e.	3	6	21	4	5.3	0.0	0.0
Panama Canal																																
Balboa Heights	118	7	97	[1]29.73	[1]29.81	−.04	80.0	+0.8	92	26	86	71	14	74	17			[2]87	10.70	+0.4	22	[3]4,188	nw.	[3]32	s.	5	0	6	25	8.5	0.0	0.0
Colon	38	7	97	[1]29.81	[1]29.82	−.02	81.0	+1.2	90	20	87	73	16	75	16			[2]86	18.02	+2.5	26	[3]5,466	w.	[3]37	sw.	25	0	7	24	8.3	0.0	0.0
Alaska																																
Juneau	80	11	50	[4]29.73	[4]29.82		43.6		54	30	48	30	10	39	18	41	37	78	11.43		22	6,417	e.	36	e.	20	3	6	22	8.1	0.0	0.0
Hawaiian Islands																																
Honolulu	38	86	100	[4]29.96	[4]30.00		77.4		84	27	82	71	10	73	13	70	66	70	0.21	−1.3	8	6,360	e.	24	e.	4	5	20	6	5.6	0.0	0.0

[1] 8 a. m. observation only. [2] Observations taken bihourly. [3] 4-cup anemometer. [4] Pressure not reduced to mean of 24 hours.

Table 2.—*Data furnished by the Canadian Meteorological Service, October, 1928*

Station	Altitude above mean sea level, Jan. 1, 1919	Pressure: Station reduced to mean of 24 hours	Pressure: Sea level reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Mean maximum	Temperature of the air: Mean minimum	Temperature of the air: Highest	Temperature of the air: Lowest	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Total snowfall
	Feet	Inches	Inches	Inches	°F.	°F.	°F.	°F.	°F.	°F.	Inches	Inches	Inches
Cape Race, N. F.	99				46.0		53.8	38.2	60	29	5.03		T.
Sydney, C. B. I.	48	29.93	29.98	+.02	48.1	+1.6	55.4	40.8	66	29	5.43	+0.74	0.5
Halifax, N. S.	88	29.95	30.06	+.06	49.1	+1.9	58.3	40.0	73	26	2.70	−2.85	0.0
Yarmouth, N. S.	65	29.93	30.00	−.02	49.1	+1.5	56.6	41.6	66	29	0.94	−3.18	0.0
Charlottetown, P. E. I.	38	29.88	29.92	−.04	47.6	+1.1	53.8	41.5	70	26	2.03	−2.87	0.6
Chatham, N. B.	28	29.87	29.90	−.06	42.7	−0.3	52.0	33.4	69	18	2.93	−0.93	T.
Father Point, Que.	20												
Quebec, Que.	296	29.70	30.03	+.03	43.7	+1.3	49.8	37.6	66	18	3.95	+0.80	1.0
Doucet, Que.	1,236				37.7		44.9	30.5	69	5	6.24		0.5
Montreal, Que.	187	29.82	30.03	+.02	47.3	+2.5	54.3	40.3	72	20	4.76	+1.63	T.
Ottawa, Ont.	236	29.77	30.04	+.03	48.1	+4.3	57.7	38.5	80	19	5.49	+2.94	T.
Kingston, Ont.	285	29.75	30.06	+.03	50.2	+3.2	56.9	43.5	70	20	4.74	+2.01	0.0
Toronto, Ont.	379	29.65	30.06	+.02	50.8	+4.2	58.8	42.8	84	23	2.94	+0.58	T.
Cochrane, Ont.	930				38.8		44.7	32.9	69	14	4.61		T.
White River, Ont.	1,244	28.63	29.96	−.02	37.7	+0.6	45.2	30.2	70	9	5.90	+3.64	3.3
London, Ont.	808				50.8		59.6	42.1	83	27	3.18		0.2
Southampton, Ont.	656												
Parry Sound, Ont.	688	29.33	30.03	+.02	47.4	+3.5	54.4	40.4	72	18	6.42	+2.50	0.3
Port Arthur, Ont.	644	29.28	29.99	+.01	43.5	+3.6	50.1	36.9	64	21	2.57	+0.01	0.0
Winnipeg, Man.	760												
Minnedosa, Man.	1,690	28.17	30.03	+.06	37.6	−0.2	47.3	27.9	62	12	0.17	−1.03	0.1
Le Pas, Man.	860				35.8		43.9	27.8	58	15	1.15		T.
Qu'Appelle, Sask.	2,115	27.76	30.05	+.08	37.8	−1.6	47.2	28.4	67	9	0.70	−0.40	1.6
Moose Jaw, Sask.	1,759				39.4		50.1	28.8	71	8	0.74		1.0
Swift Current, Sask.	2,392	27.44	29.99	+.02	39.5	−2.6	50.9	28.0	68	16	0.80	−0.08	2.4
Medicine Hat, Alb.	2,144												
Calgary, Alb.	3,428												
Banff, Alb.	4,521												
Prince Albert, Sask.	1,450	28.44	30.04	+.07	37.8	+0.7	46.5	29.1	61	7	0.59	−0.24	0.1
Battleford, Sask.	1,592	28.26	30.03	+.06	37.6	−2.0	48.0	27.3	65	6	0.35	−0.10	T.
Edmonton, Alb.	2,150												
Kamloops, B. C.	1,262												
Victoria, B. C.	230	29.80	30.06	+.05	49.8	+0.6	53.7	46.0	63	41	3.58	+1.21	0.0
Barkerville, B. C.	4,180												
Estevan Point, B. C.	20												
Prince Rupert, B. C.	170												
Hamilton, Ber.	151	29.99	30.15	+.13	73.6	+0.6	80.1	67.0	84	62	6.48	−0.23	0.0

LATE REPORTS, SEPTEMBER, 1928

Station	Altitude above mean sea level, Jan. 1, 1919	Pressure: Station reduced to mean of 24 hours	Pressure: Sea level reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Mean maximum	Temperature of the air: Mean minimum	Temperature of the air: Highest	Temperature of the air: Lowest	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Total snowfall
Father Point, Que.	20	29.96	29.98	.00	48.8	−1.6	56.8	40.8	72	30	1.96	−1.17	0.0
Winnipeg, Man.	760	29.11	29.94	.00	53.7	+1.2	64.8	42.7	81	29	0.64	−1.39	0.2
Kamloops, B. C.	1,262	28.68	29.96	−.01	59.3	+1.9	71.5	47.2	92	38	0.37	−0.48	0.0
Barkerville, B. C.	4,180	25.69	29.99	+.01	46.8	+0.1	58.6	35.1	74	23	2.24	−0.67	0.7
Estevan Point, B. C.	20				52.6		58.3	47.0	70	42	4.08		0.0
Prince Rupert, B. C.	170				53.4		59.6	47.2	76	40	7.91		0.0

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Chart I. Departure (°F.) of the Mean Temperature from the Normal, October, 1928

Chart I. Departure (°F.) of the Mean Temperature from the Normal, October, 1928

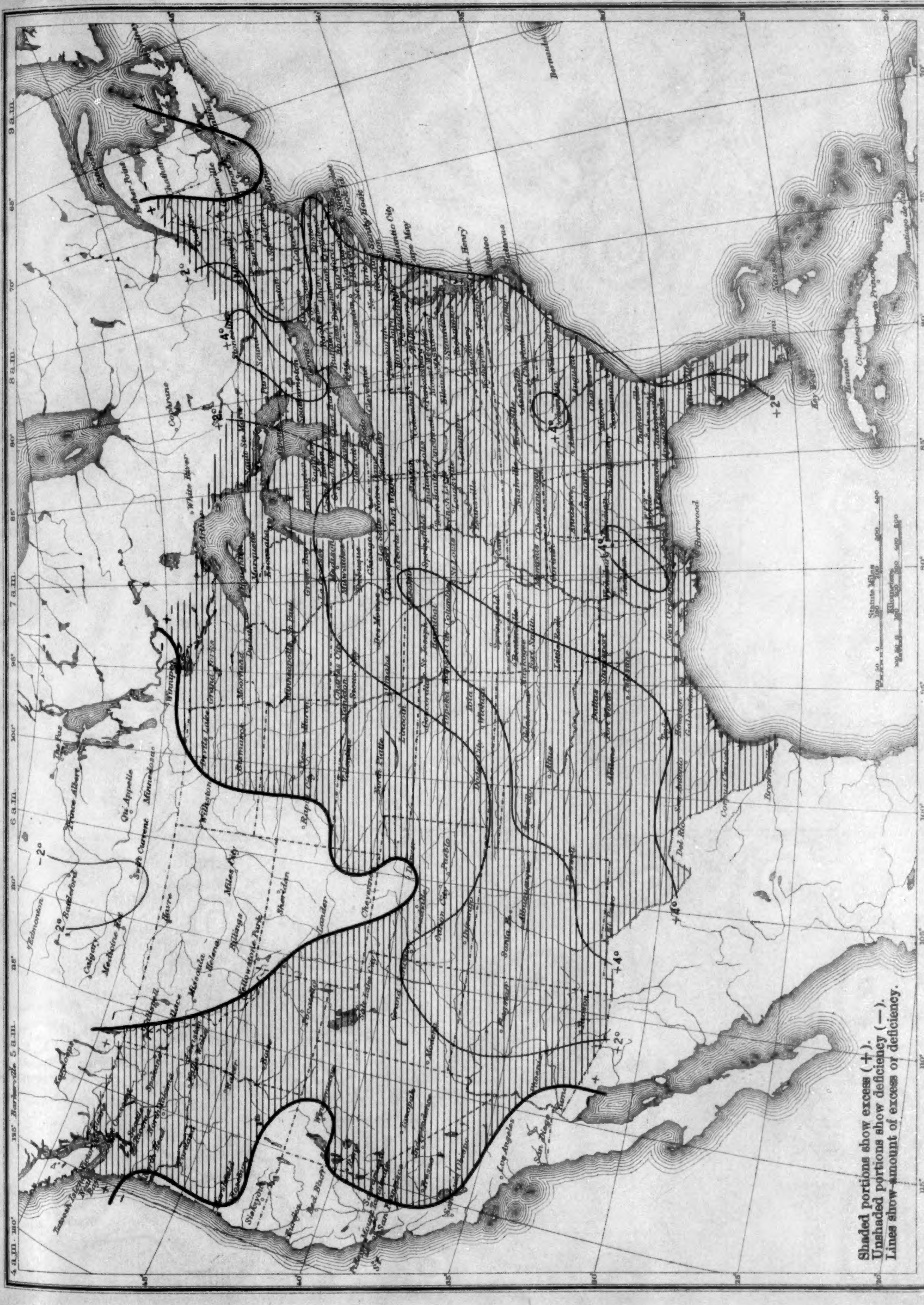

Chart II. Tracks of Centers of Anticyclones, October, 1928. (Inset) Departure of Monthly Mean Pressure from Normal
(Plotted by Wilfred P. Day)

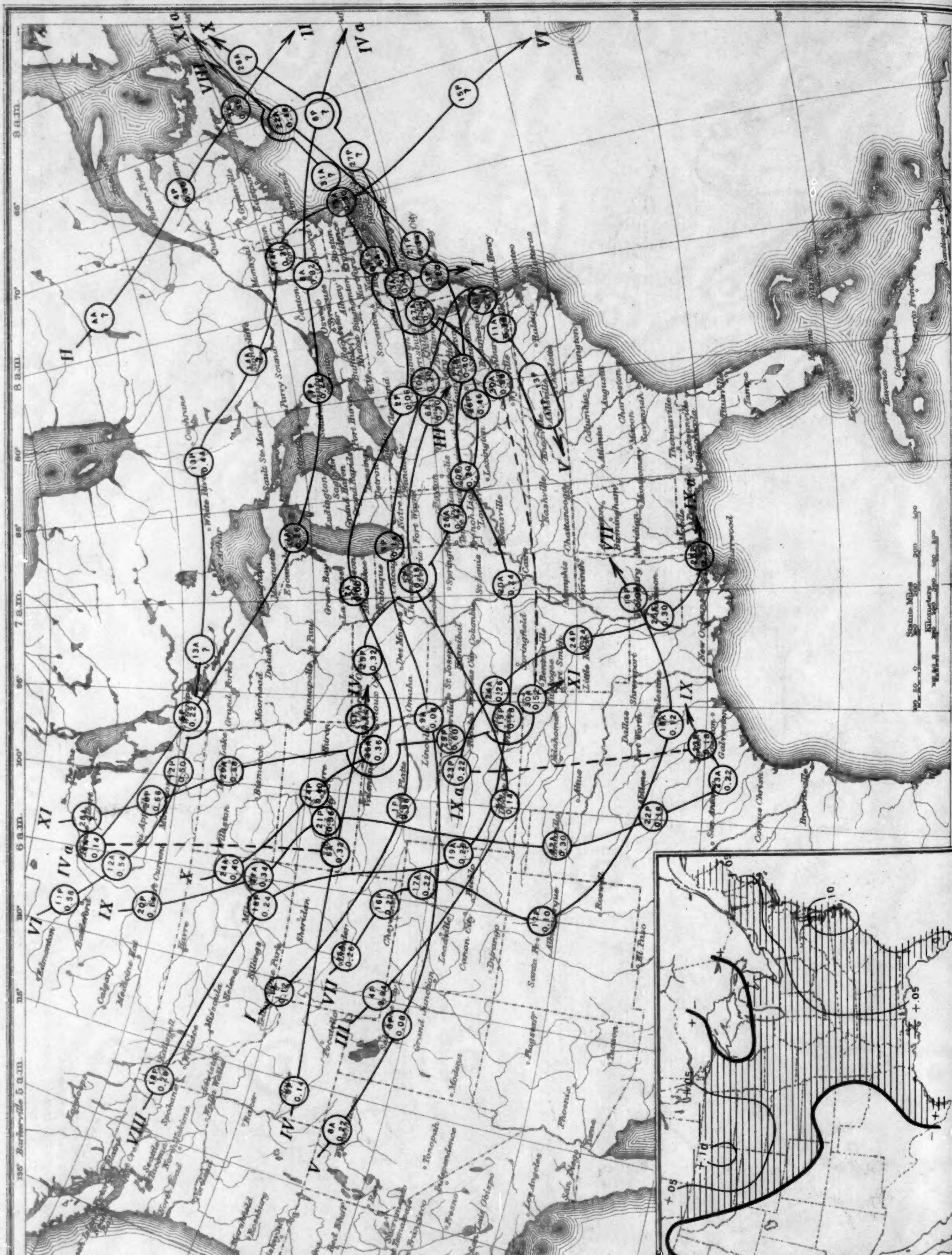

Chart III. Tracks of Centers of Cyclones, October, 1928. (Inset) Change in Mean Pressure from Preceding Month
(Plotted by Wilfred P. Day)

Chart III. Tracks of Centers of Cyclones, October, 1928. (Inset) Change in Mean Pressure from Preceding Month
(Plotted by Wilfred P. Day)

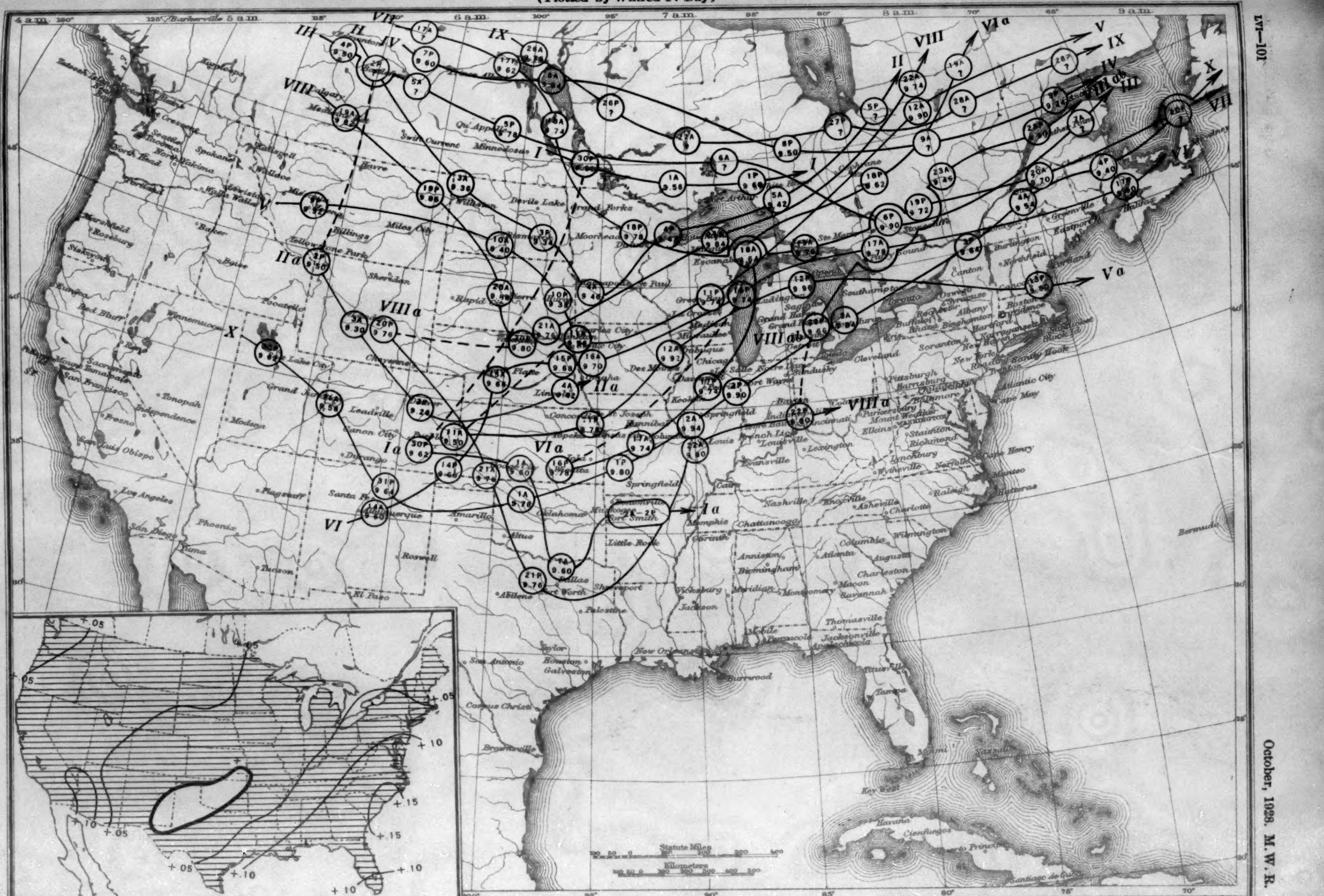

Chart IV. Percentage of Clear Sky between Sunrise and Sunset, October, 1928

Chart V. Total Precipitation, Inches, October, 1928. (Inset) Departure of Precipitation from Normal

Chart V. Total Precipitation, Inches, October, 1928. (Inset) Departure of Precipitation from Normal

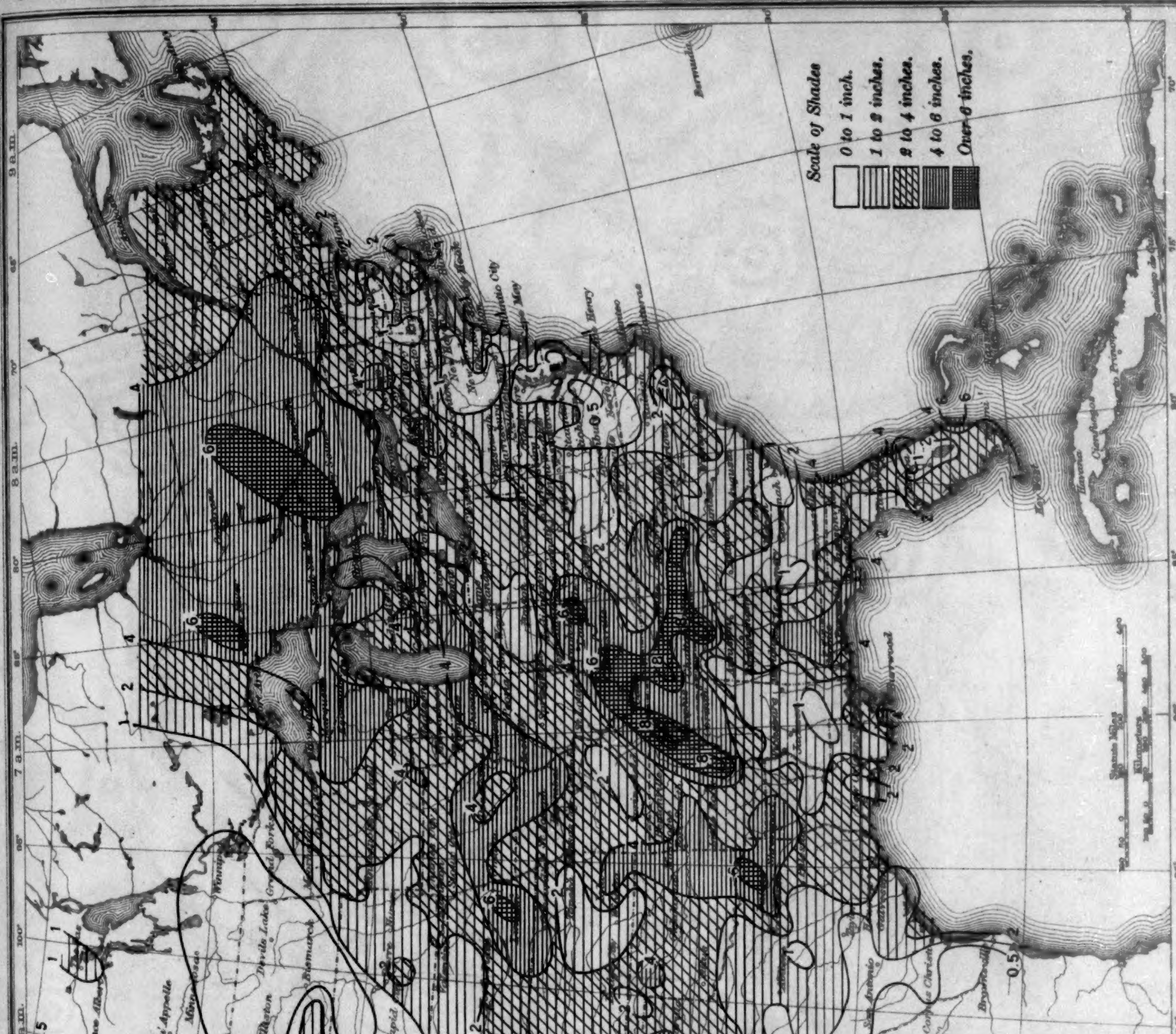

Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, October, 1928

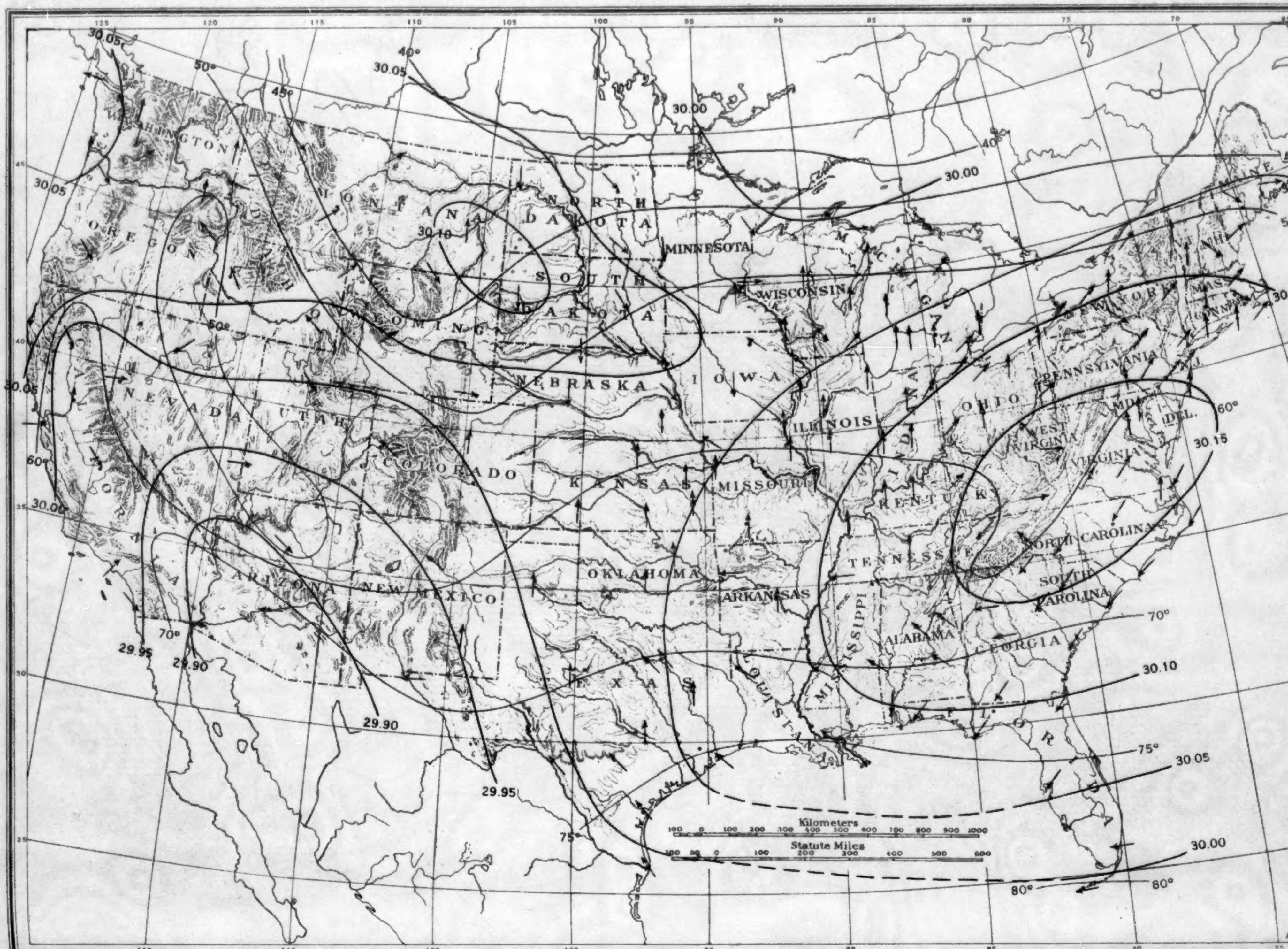

Chart VIII. Weather Map of North Atlantic Ocean, October 11, 1928
(Plotted by F. A. Young)

Chart VIII. Weather Map of North Atlantic Ocean, October 11, 1928
(Plotted by F. A. Young)

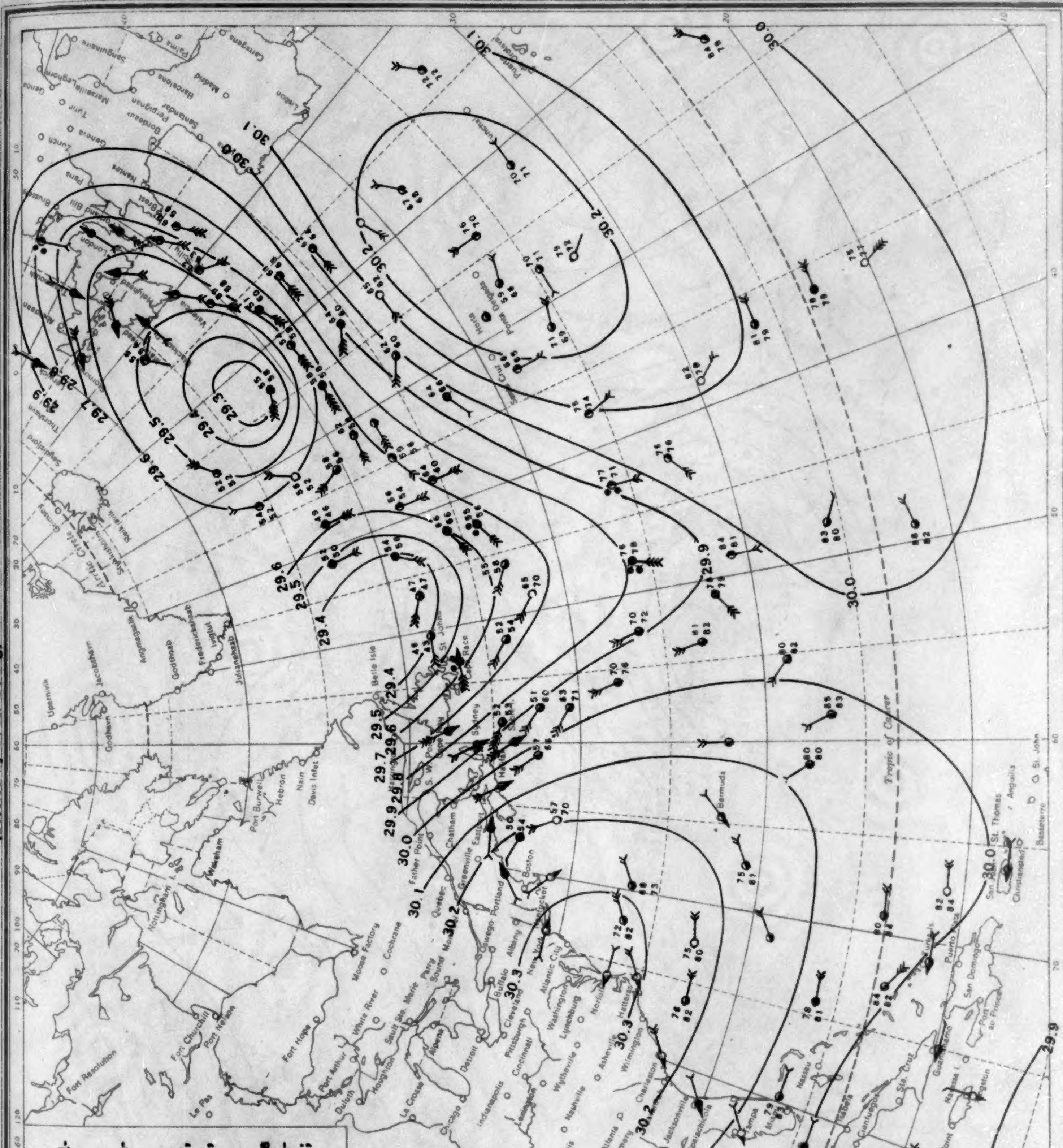

Chart IX. Weather Map of North Atlantic Ocean, October 12, 1928

(Plotted by F. A. Young)

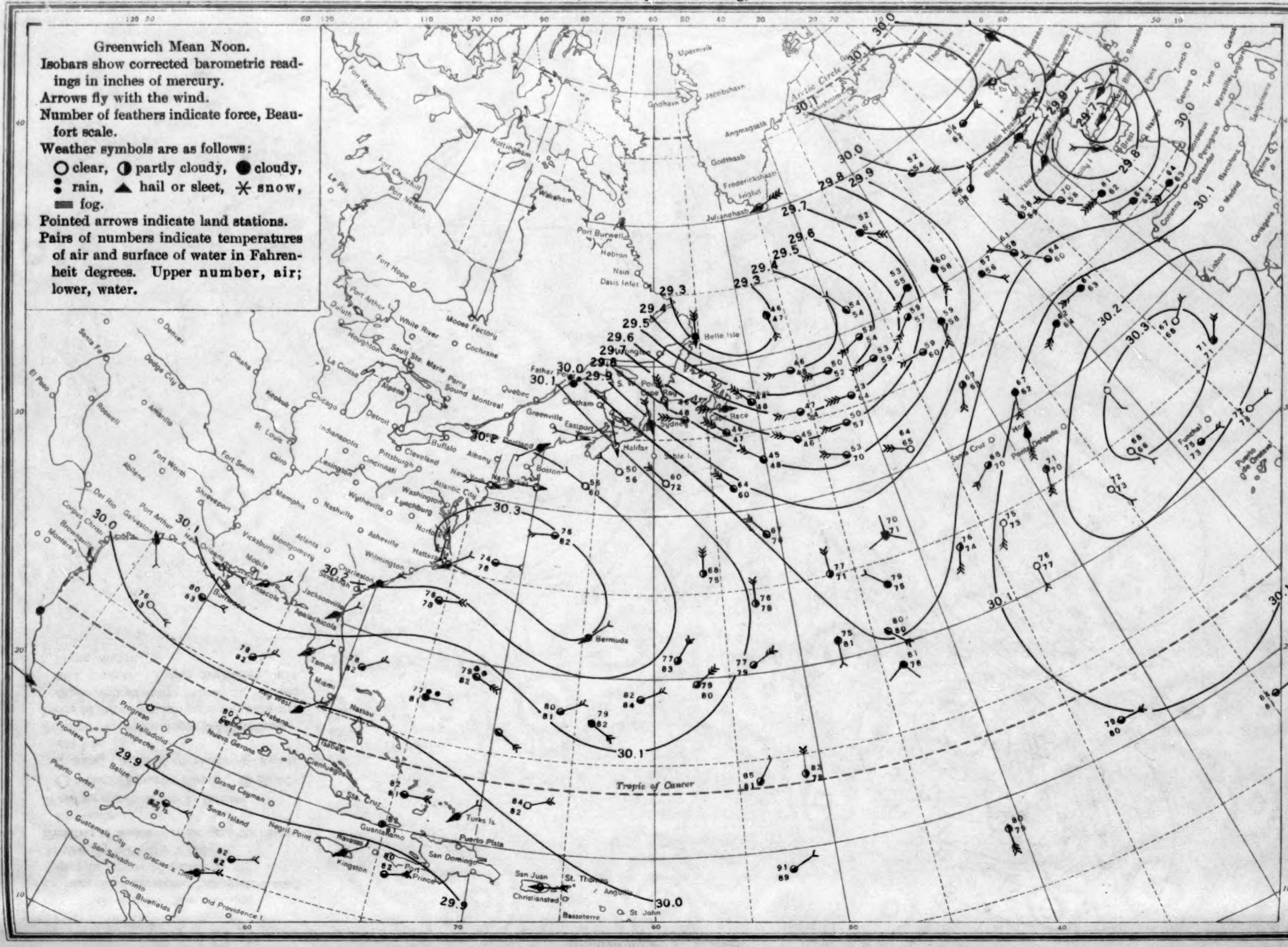

Chart X. Weather Map of North Atlantic Ocean, October 13, 1928

(Plotted by F. A. Young)

Chart X. Weather Map of North Atlantic Ocean, October 13, 1928
(Plotted by F. A. Young)

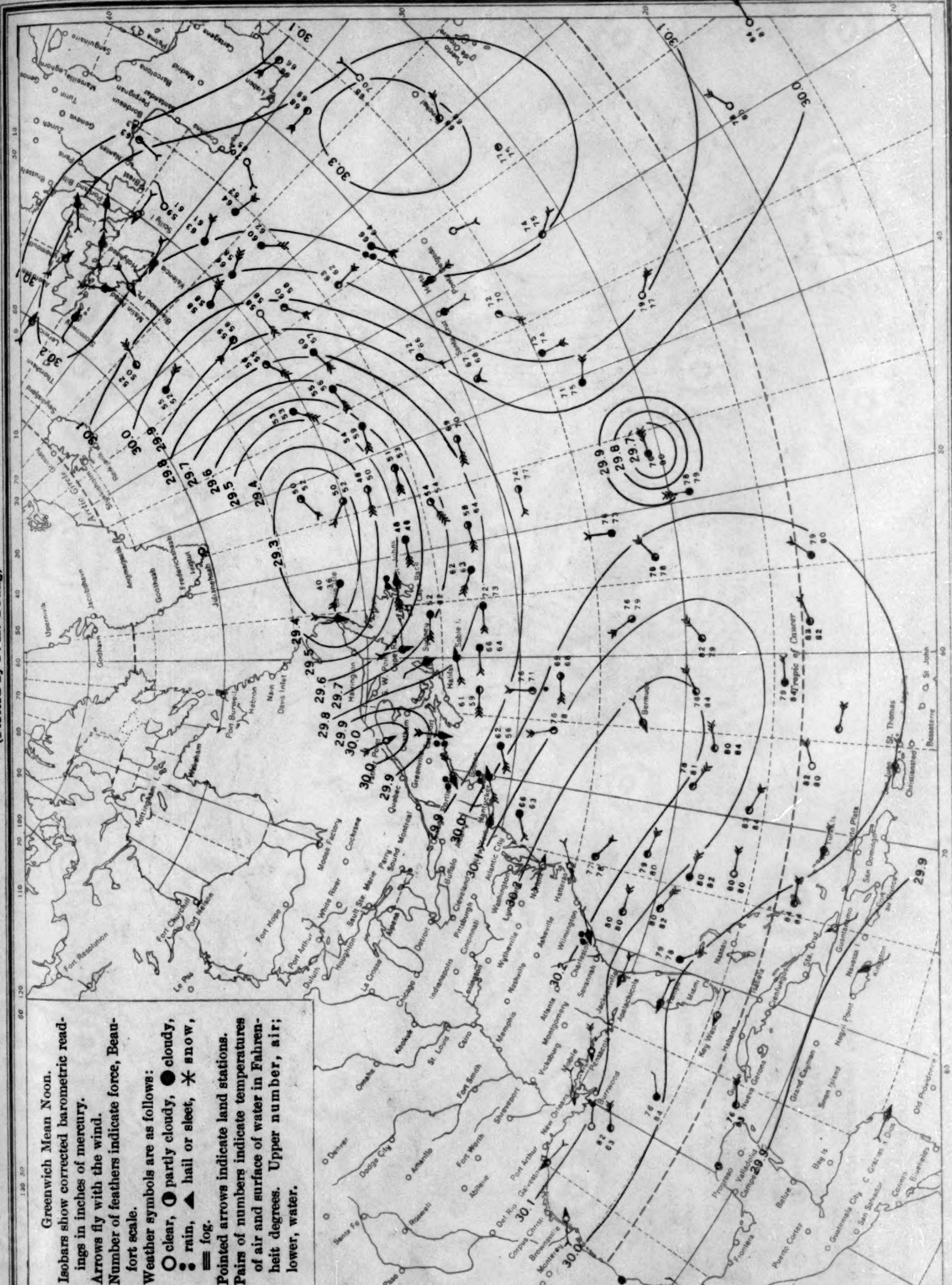

Chart XI. Weather Map of North Atlantic Ocean, October 14, 1928
(Plotted by F. A. Young)

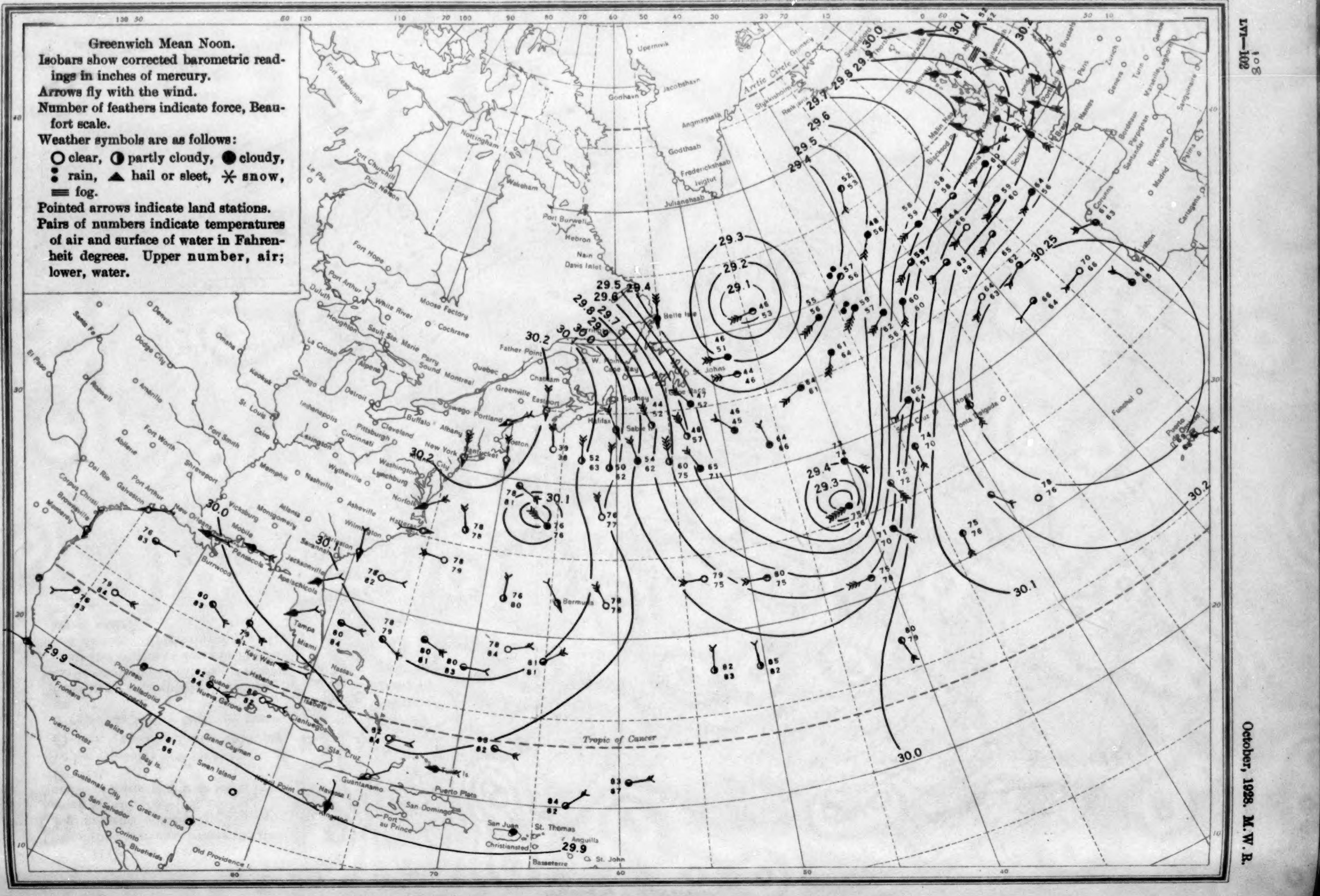

Chart XII. Weather Map of North Atlantic Ocean, October 15, 1928

(Plotted by F. A. Young)